COMPLETE SCENES BROADCAST

6d MONTHLY

Television

The Official Organ of the Television Society

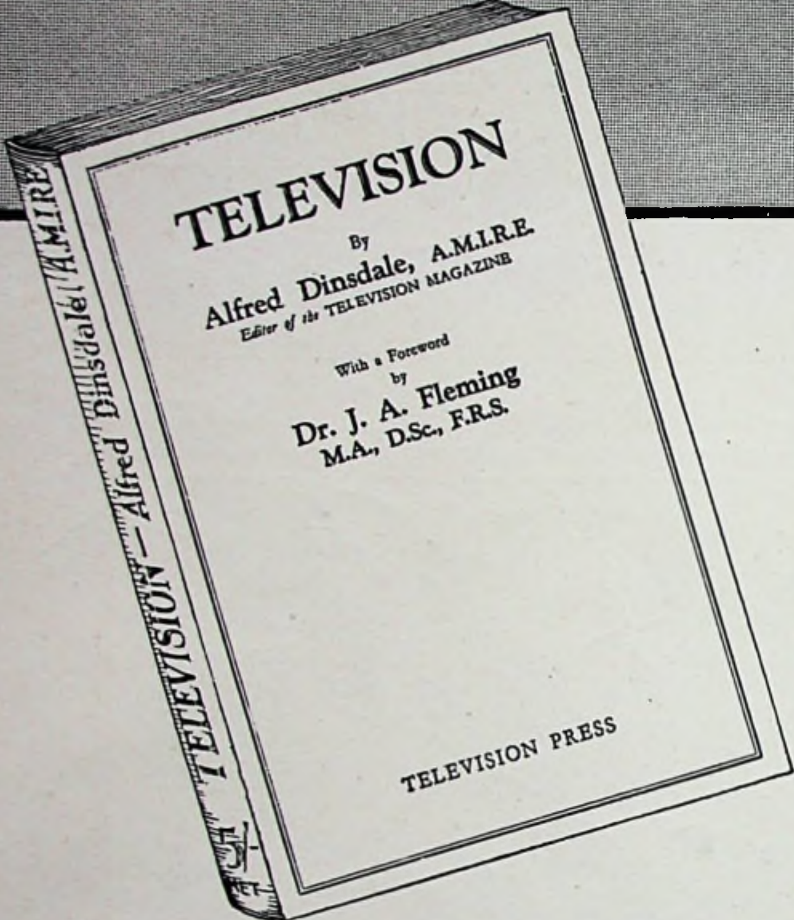
VOL. 1 FEB. 1929 No. 12

BIBLIOTHEEK
N.V.H.R.

A scene from the play " Box and Cox," the speech and scenes of which were broadcast on December 15th last from the Baird Company's Experimental Station in London. The scope of the apparatus has been extended so that complete scenes like that shown above, and elsewhere in this issue, can now be televised in their entirety, thus vindicating the mechanical spotlight system.

Read Dr. Tierney's article on page 5.

THE WORLDS FIRST TELEVISION JOURNAL



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The Foreword is written by Dr. J. A. Fleming, F.R.S.

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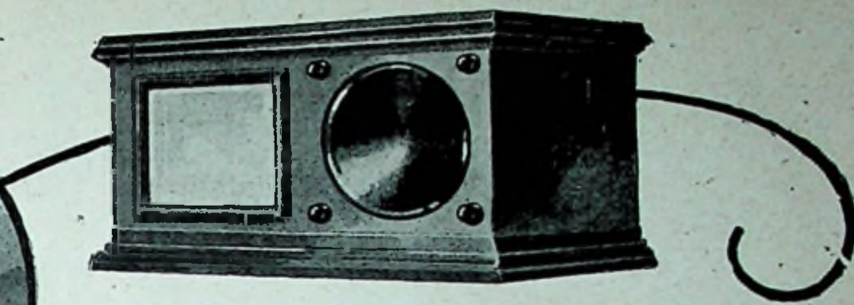

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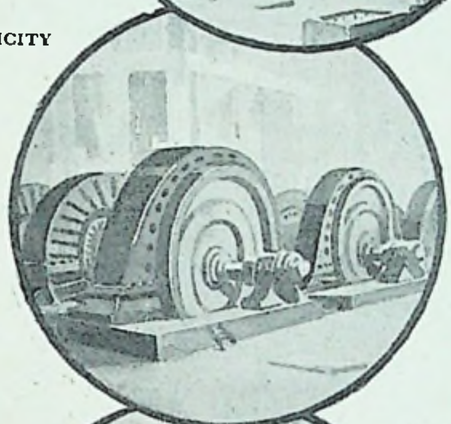

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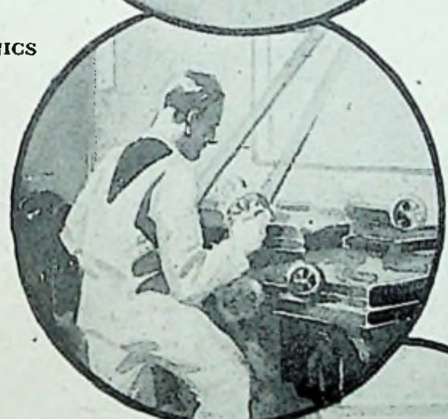

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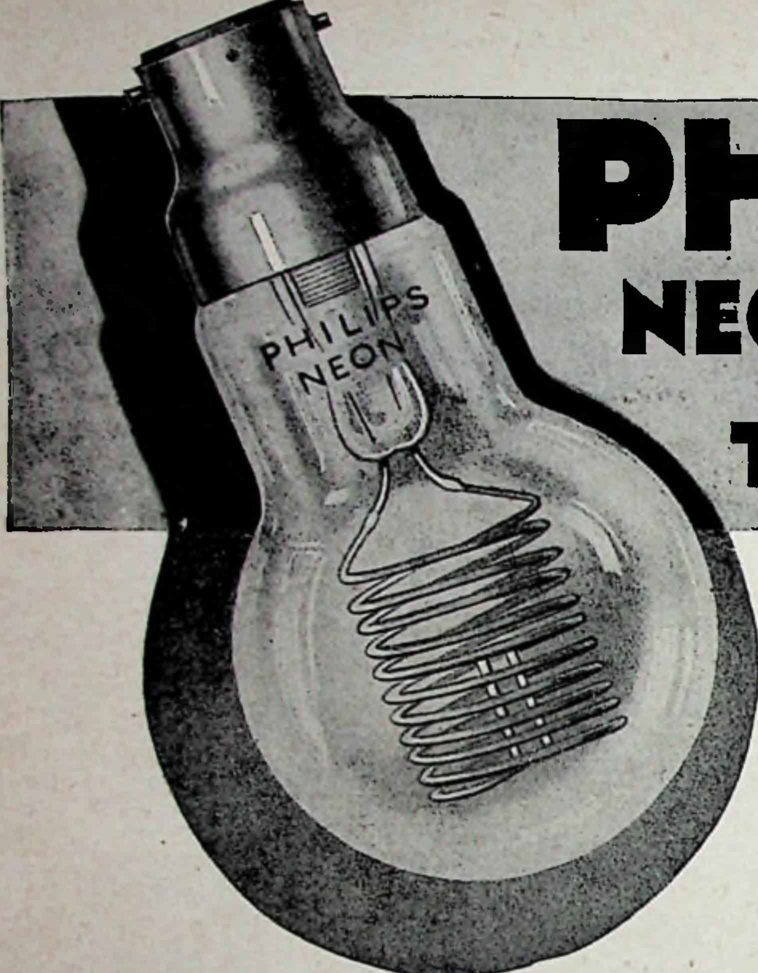

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Television

THE WORLD'S FIRST TELEVISION JOURNAL

The Official Organ of The Television Society

Edited by A. DINSDALE, A.M.I.R.E.

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Technical Editor: J. C. RENNIE, B.Sc., A.M.I.E.E.

Vol. 1] FEBRUARY 1929 [No. 12

EDITORIAL

TELEVISION IN HOLLAND.

IN our October number we published a photograph of the Baird Company's stand at the Industrial Exhibition in Rotterdam, and intimated that actual demonstrations of television were then in progress. Amongst those who witnessed these demonstrations was the Crown Prince of the Netherlands.

* * *

INTEREST in television has been very keen in Holland for some time, and the demonstrations stimulated that interest still further. Amongst commercial concerns which became interested is the well-known firm of N. V. Philips Radio, whose efforts to produce television in their own research laboratories is described in our Dutch contemporary, *Radio Wereld*, of January 3rd.

* * *

THE name of the engineer in charge of the experiments is given as Dr. Druyvensteyn, and his efforts, according to the description given, together with photographs of the apparatus, were confined to an attempt to reproduce as nearly as possible the spot-light apparatus used by Baird. The experiments, apparently, did not meet with very much success, and this is admitted by Dr. Druyvensteyn himself and by officials of the Philips Company.

* * *

WE are not surprised at this, because, especially in the case of such a new invention as television, concerning the technique of which but little is generally known, it is hardly reasonable to expect even the most expert engineers to duplicate successfully in a short period of time an assemblage of apparatus which it has taken Baird himself years to perfect.

* * *

WHAT does surprise us is the fact that *Radio Wereld*, just because these experiments did not meet with success, takes advantage of the opportunity to make some very disparaging remarks concerning the present state of the art. No one is justified in criticising the present

Editorial & Publishing Offices:

The Television Press,
Limited,

26, Charing Cross Road,
London, W.C.2.

Telephone: Regent 6437.

SUBSCRIPTION RATES, 7/6 PER ANNUM, POST FREE.

MSS. and other material for Editorial consideration should be accompanied by a stamped addressed envelope, and should be typewritten.

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state of television who has not been to London and witnessed a recent demonstration of what can and is being done daily in the Baird Laboratories.

* * *

CRITICS DISCREDITED.

A LARGE number of critics of television, many of them with distinguished names, have stated not once but many times, and at great length, that television could never be successfully accomplished by mechanical methods. When Baird proved that it *could* be successfully accomplished, and while he was publicly demonstrating television images the scope of which enabled the head and shoulders of a person to be reproduced, the critics, being forced to admit that mechanical methods were successful, minimised that success to the best of their ability and stated in unequivocal terms that it would be impossible to increase the field of vision by mechanical methods and televise anything but small objects such as a person's head.

* * *

MR. BAIRD, retaining his faith in his mechanical methods, continued his researches, with the results set forth in an article by Dr. C. Tierney, D.Sc., F.R.M.S., which appears on another page of this issue. The British inventor has so far perfected his system that it is now possible to televise whole scenes in which appear, full length, several people at a time. The received images as reproduced on the standard home televisor, though smaller, are nevertheless quite as completely recognisable.

* * *

A FURTHER development described by Dr. Tierney relates to the projection of the received images on to a screen some four feet in diameter. Such a size of screen makes it possible to demonstrate television to a number of people at once. It could, in fact, be employed in a small hall. This marks the first step towards the ultimate development of the *size* of the image to cinema screen dimensions, so that audiences in picture theatres may witness a reproduction, not of something which happened some time previously as is the case with a cinema film, but of something which is actually happening at the moment of presentation.

* * *

SURELY these improvements constitute a vindication of mechanical methods of image scanning, and serve to discredit the theorists and armchair critics.

BRITAIN BEFORE CONTINENT

TELEVISION SOCIETY IN BELGIUM.

THROUGH the courtesy of the founder we are able to announce that there is about to be formed in Brussels a "Société Scientifique de Television." This society will hold its first meeting and arrange its constitution very shortly. The Founder and Secretary (*pro tem.*) is Ch. Gheude Ing., Chaussée de Tervueren, 87, Auderghem-Bruxelles, who has very kindly promised to keep us informed as to the activities of the new society. We take this opportunity of congratulating M. Gheude on his enterprise, and we feel sure that our readers will join us in expressing our best wishes for the Society's future.

NEW TELEVISION COMPANY IN AMERICA.

ONE of the most important events which have occurred in connection with television on the other side of the Atlantic is the formation, last December, of a ten million dollar (two million sterling) company to finance the sale of television transmitters and receivers developed by Mr. C. Francis Jenkins, of Washington, D.C., whose shadowgraph film transmission and reception apparatus was recently described in these pages.

* * *

THE exact nature of the apparatus which the new company proposes to market has not yet been announced, but the company is stated to be backed by a group of financiers whose names are so well known in the American financial world that great things are expected of the organisation. Mr. A. J. Drexel Biddle, Jr., is quoted as being chairman of the board of directors.

* * *

IN THIS ISSUE.

THE subject of cathode rays in connection with television is of such interest and possible importance that, following Mr. H. Wolfson's article on the subject last month, we publish in this issue a further exposition of the subject by Mr. W. G. W. Mitchell, B.Sc. Mr. Mitchell has made some extended researches into the subject, and we feel sure that his article will be read with great interest.

* * *

FOLLOWING up our suggestion, made on this page last month, that it is high time some new principle was discovered in connection with the modulation of broadcast transmitters, we print on another page a review of the position as it is to-day, together with some details of alternative methods which have been suggested. Further research on the subject is urgently needed.

The Future of Television

By Dr. C. TIERNEY, D.Sc., F.R.M.S.

Vice-President and Chairman of the Executive of the Television Society.

WE have recently read in a leading London newspaper, the *Morning Post*, a report of an interview between its representative and an official of the B.B.C., which purports to challenge Mr. J. L. Baird to come forward with any new development which will enable them to reconsider the question of affording facilities for broadcasting television. Without entering into any discussion as to the merits or demerits of this mode of negotiation, or whether the desired end is not more likely to be achieved by co-operation rather than by pseudo challenges, a few observations upon the results of some recent tests will be of interest.

While theorists are still debating whether the disc and spot-light method of exploring is capable of scanning anything more than a very small object, and whilst they are theorising on the speed of the disc in terms of millions of revolutions per second which make one giddy to read, what are the facts? J. L. Baird has repeatedly demonstrated to scientific and other competent observers, as well as to the public, the adequacy of his own method for the transmission and reception of televised images.

The image of the head and shoulders of the subject is received with complete satisfaction to all, and more recently he has transmitted *a whole stage scene* showing two athletes giving an exhibition boxing-bout to demonstrate the practical application of his system to larger scenes. The latter demonstration, which the writer, amongst others, was privileged to witness, was carried out from a stage some 15 feet by 10 feet, temporarily constructed for the test.

The scene, received in another room of the same building, clearly depicted the small, but recognisable, images of the combatants and their every movement, which at times were particularly rapid, as blow upon blow was exchanged, and one or other would speedily dodge or retreat in order to escape an impending disfigurement. The reception only needed the loud-speaker attachment to render audible the exchange of blows, and perhaps the remarks, to complete the realism.

Dr. C. Tierney, D.Sc., F.R.M.S., Vice-President and Chairman of the Executive of the Television Society.

A further difficult and exacting test was carried out with equally satisfactory results. **A cyclist, riding a bicycle round a ring, illuminated by the same method, was transmitted to the same receiver, which accurately showed every movement, both of the machine and the rider in motion and without any question as to identity or direction of movement, which abundantly justified our expectation.**

I have referred to these two experimental tests in order to show the practical application of the Baird system to extended scenes, and if further evidence were necessary to emphasise the possible development and potentiality of this system I may perhaps be permitted to refer to the subject of projected television, i.e., the projection of the image on to a large screen.

In company with a number of distinguished visitors to Mr. Baird's laboratories, I subsequently witnessed the received image of a well-known person **projected on to a screen some four feet in diameter, which could be seen and recognised by a large audience.** The result, though as yet not fully developed, was astonishing. Not only was every movement of the head, the eyes, the lips, etc., reproduced with fidelity, but also those subtle expressions of pleasure or annoyance, of joy or grief, truthfully portrayed.

These few facts alone are sufficient

"WHO'S ROOM IS THIS?"

A scene from the play "Box and Cox," which was broadcast, both orally and visually, from the Baird Company's experimental transmitter at Long Acre. The entire scene, as photographed, was televised.

to show that **there is in these developments a potentiality as yet unappreciated in this country.** Foreign governments and powerful organisations from abroad are concerned to acquire rights and privileges in these which our own authorities are so reluctant to secure, and which, in the opinion of those experts most competent to judge, are more than sufficiently advanced to justify trial through any of the British broadcasting stations, all of which, for good or ill, the B.B.C. is granted the monopoly.

It is alleged, but without adequate reason, that television broadcasts would cause interference with the already overcrowded broadcast waveband, which allegation has been repeatedly disputed. It is not denied that the broadcast wave-band is congested, and none know better than the B.B.C. engineers and listeners alike the disappointment and difficulty of maintaining twenty-one stations in this country free of interference. But the obvious remedy which is at last being adopted is fewer and higher-power stations as contemplated in the Regional Scheme.

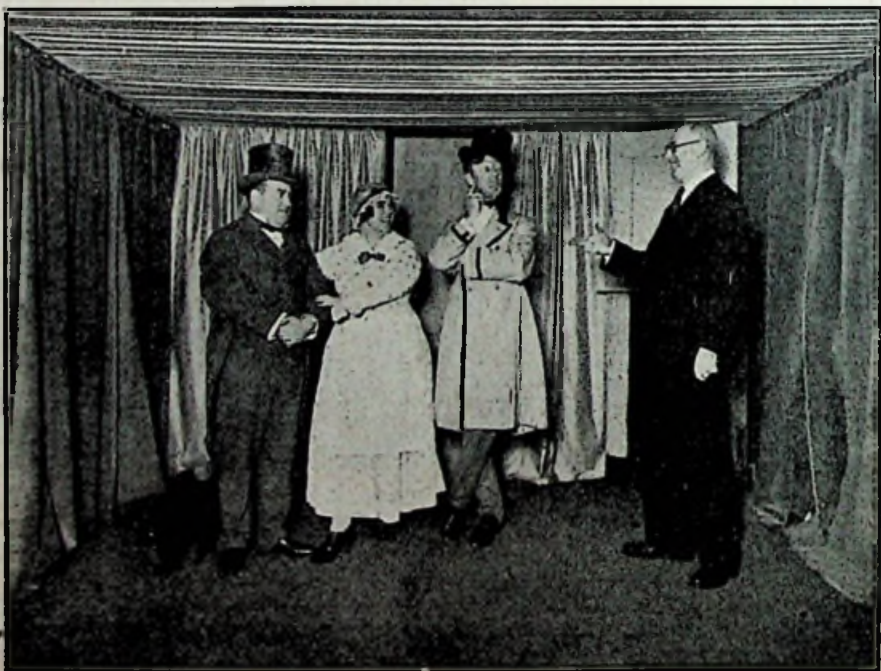
What, then, can be the reason for refusing the public demand for a broadcast television service?

One hesitates to think there is any design in this refusal, but the fact remains that progress is obstructed, and neither the experimental worker nor the public, who are the final judges, are afforded the service which is demanded. It is seldom that any good comes from such obstruction. On the contrary, progress is more readily achieved by co-operation and goodwill.

Our present broadcast system was not perfected in its first year of service, nor indeed, while fully appreciating its excellence, is it perfect yet; but if, in the matter of television, the British public is expected to be satisfied with the transmission of still pictures when the living image is as readily available, then **those responsible for the delay are failing in their duty to their employers and to the public in whose hands the ultimate remedy lies.**

Many listeners must have heard more than once the announcers regret that they could not see some particular artist giving a performance before the microphone. I recently heard a well-known actor introduced to listeners as follows:—"Here is Mr. ——, who has called at the studio on his way to the theatre. He is dressed up in all his war-paint; **I wish you could all see him,** he is going to sing ——." Now there must be a large number of listeners who know that that is the very subject which could have been broadcast by television with satisfaction had the facilities been available for the purpose.

To challenge Mr. Baird to produce anything new may appear very



REHEARSAL OF "BOX AND COX."

Right to left: Mr. Gordon Sherry (producer), Mr. Lawrence Baskomb (Box), Miss Vivienne Chatterton (Mrs. Bouncer), and Mr. Stanley Vilven (Cox)—*and* the Television Cat.

heroic, but it sounds rather like the smarting boy who whistles to keep his courage up. In any case, it is not "challenges" but co-operation and a fair trial that the public would welcome.

The present attitude of the B.B.C. is by common consent a fundamental mistake, and it is to be hoped that their mode of remedying this is not so insincere as it at first appears, and that the British public may yet have a British system of television which, in spite of ill-formed opinions to the contrary, is more advanced and more promising than any other.

None but a very young or very stupid person would either claim or expect perfection from these early developments. There are, unquestionably, difficulties which demand combined effort and a fuller knowledge for their solution, and when it is remembered that it has taken over thirty years' concentration of the world's best brains, and millions of public money to develop our present wireless services, and these are not perfect yet, it is the more amazing that television has reached so remarkable a stage of development in so short a space of time.

It is safe to say that television is many, many years ahead of where wireless was when that first started. We have no hesitation in stating that had this country turned down wireless in those early days because of the crudity and imperfections of the coherer and decoherer, Britain would not hold the position it controls to-day in wireless telegraphy and telephony; and when a prominent member of the B.B.C. staff, who wisely, or otherwise, posing as an *unbiased technician*, states in reference to the Baird system of television that "quantities beat it," whatever that might mean, he is speaking with insufficient knowledge and without authority.

We have instances enough in this country of the folly of waiting for perfection before we condescend to consider important inventions which have gone abroad for development, resulting in huge industries. The cinematograph is a conspicuous evidence of this, and if through garrulous ineptitude television is similarly compelled to go abroad for its development and practical application, then the loss will be to British workers and a scandal to British enterprise and British genius.

TELEVISION DOES THE TRICK!

By W. BATESON

DEFTLY, silently, Harry moved the radio-televisor until the mirror was directly in front of Mr. Beaumont. He felt confident that his grumpy, obstinate father would not remove the newspaper from in front of his eyes until after Grace's appearance. She was due in two minutes. If only Dad would look, he'd be won over all right. Who could withstand the appeal of those lovely grey eyes?

The *Broadcast* announced that at six-thirty Miss Grace Meadows, the famous actress, would make her appeal to the whole nation for money to carry on her work in the East End of London.

The whole nation! Ye gods! All he wanted was a successful appeal to one disagreeable old man, who hated all actresses.

He switched on the set, and in a few seconds the deep chimes of Big Ben filled the room.

"Can't you do without that damned thing for one evening of your wasted life?" A petulant, complaining voice came round the paper. "A man can't get any peace in his own house nowadays; every night noisy jazz-bands, shrieking actresses asking for money for a cause they know nothing about. Grrrrrrrr!" The paper rustled ominously.

"There she is," Harry cried excitedly, "isn't she perfect?" Unintelligible sounds issued from behind the newspaper.

"Good evening, everybody," came a sweet young voice through the loud-speaker. "I do hope my appeal is going to be successful. Let me tell you of some of the children I have been with to-day . . ." As the voice went on the newspaper slowly descended.

Slowly, slowly. Harry, watching eagerly, could just see the shiny top of his father's bald head. "Come on, Dad," he said ingratiatingly, "be a sport and have a look." The newspaper shot back to its original position with a jerk. Harry groaned; he had only another five minutes in which to make the old man look at the televisor.

"Obstinate old devil," he thought disrespectfully. He knew Mr. Beaumont was simply aching to look. His curiosity was a standing joke.

"I'm sure," the voice from the loud-speaker was saying, "that there are some nice elderly gentlemen listening to my appeal, who will help in my efforts to alleviate the sufferings of the poor children. I say 'elderly' because I like elderly men. Young men are very nice, but they are not, as a rule, blessed with a great amount of sense, and . . ."

The newspaper came much lower than before. Harry could now see the busy eyebrows sticking up over the top of the paper. Lower still, the stern old eyes were peering over their silver-rimmed glasses, straight into the beautiful grey eyes of Grace Meadows. He continued to stare for a few minutes, the newspaper falling, unheeded to his knees, the old eyes softening. He glanced across at Harry with a sheepish grin, jumped up, and walked over to the radio set.

"You don't know much about this set, Harry," he complained, irritably fussing with one of the gleaming knobs on the panel. "You haven't got the face very clear."

A broad grin spread over Harry's face. "Victory," he told himself exultantly, "Victory, the old man's fell!!!" with a complete disregard of the King's English.

The picture of Grace faded from the mirror, and Mr. Beaumont switched off the set, with something very like a sigh of regret. He gazed sternly over his glasses at Harry. "You should have told me that she was pretty," he accused him, "and —er—that she—er—liked old men," he finished lamely.

"But, Dad—I—"

"Don't interrupt," he snapped, "are you seeing her to-night?"

"Yes, I was to call at the broadcasting station for her."

"Very good, then. Bring her round here."

"But Dad, this is perfectly . . ."

"Will you never learn to do as you're told, Harry?" Mr. Beaumont said complainingly.

MORE ROOM IN THE ETHER

By THE EDITOR

According to Captain Eckersley, the Chief Engineer of the B.B.C., a new and radical discovery is required before television will ever be successfully accomplished. We pointed out in our Editorial last month that, if a new discovery is required, it is in connection with *wireless.* The technique of television has already reached a much higher standard than that attained by wireless telephony when broadcasting first started. Television technicians have certainly done their part. It is now up to the wireless technicians to find a way to open up the ether and increase the number of channels of communication available for dual broadcasting purposes.

The following article points out clearly the extent of the waveband wastage caused by present methods of modulation, explains alternative systems which have been developed, and indicates the lines along which further progress is required.

THE most pressing need in broadcasting at the moment is more room in the ether. In America, where there are 700 broadcasting stations, the position has been acute for several years. Difficulties have also been experienced in Europe during the past few years, and with new transmitters constantly being opened up, or the powers of existing ones increased, the European situation is rapidly becoming impossible. All these stations have to transmit on what we now consider to be narrow wavebands between 200 and 600 metres, and between 1,000 and 2,000 metres.

These limits are accepted by international agreement, and are arranged to prevent interference with service and commercial stations. In the ether space allotted to broadcasting stations it has been laid down that there must be a spacing between stations of at least 10 kilocycles (10,000 cycles). Such spacing is designed to give freedom from heterodyning and interference between stations, and provides accommodation for about 113 stations in all, each operating on its own exclusive wavelength.

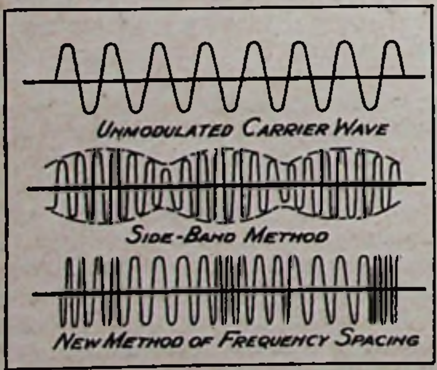


Fig. 1.

Under the present system of modulation, speech and music are superimposed upon the carrier wave of a broadcast station by what may be termed " amplitude " or intensity modulation. That is to say, the amplified currents from the microphone are alternately added to and subtracted from the strength of the carrier wave. In Fig. 1 the top curve represents the unmodulated carrier wave upon which the speech currents must be superimposed. The second curve shows the effect which modulation by the present, or sideband method, has on the carrier wave.

There is another way of presenting the case diagrammatically which may make the subject clearer.

If a broadcast transmitter is sharply tuned and has little damping, the " resonance curve " of its unmodulated carrier wave will appear as depicted in Fig. 2. It will be noted that nearly all the energy of the wave is concentrated (as represented by the peak of the curve) on a frequency of 1,000 kilocycles, which corresponds to a wavelength of 300 metres.

As soon as the carrier wave is modulated by speech currents, however, the resonance curve takes on a totally different appearance, as depicted in Fig. 3. It is only possible, in such a diagram, to show a few of the thousands of frequencies which are actually present. As will be seen, the parasitic frequencies, as they might be termed, extend from 990 kc. to 1,010 kc., or over a frequency band 20 kc. wide.

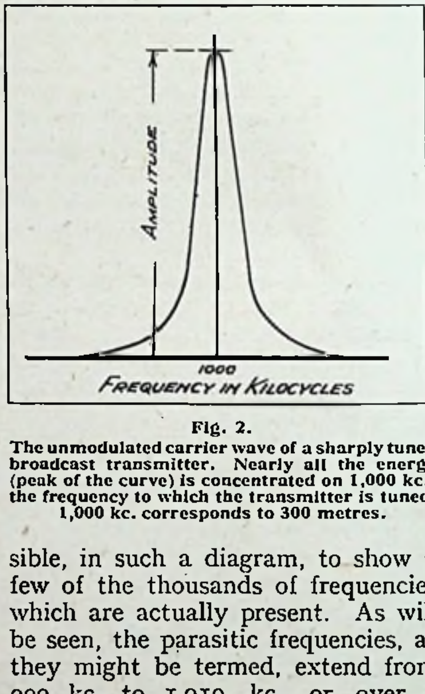


Fig. 2.
The unmodulated carrier wave of a sharply tuned broadcast transmitter. Nearly all the energy (peak of the curve) is concentrated on 1,000 kc., the frequency to which the transmitter is tuned. 1,000 kc. corresponds to 300 metres.

It would appear from Fig. 3, therefore, that in order to give broadcasting stations an ideal amount of " elbow room " they ought to be separated by 20 kc. instead of 10 kc., as is actually the case. Closer examination, however, will reveal the fact that between 995 kc. and 990 kc., and between 1,005 and 1,010 kc. the amplitude, or energy of the sideband waves falls off very rapidly. This means that the effective range of these extreme frequencies on the " skirts " of the curve is very low, and that the

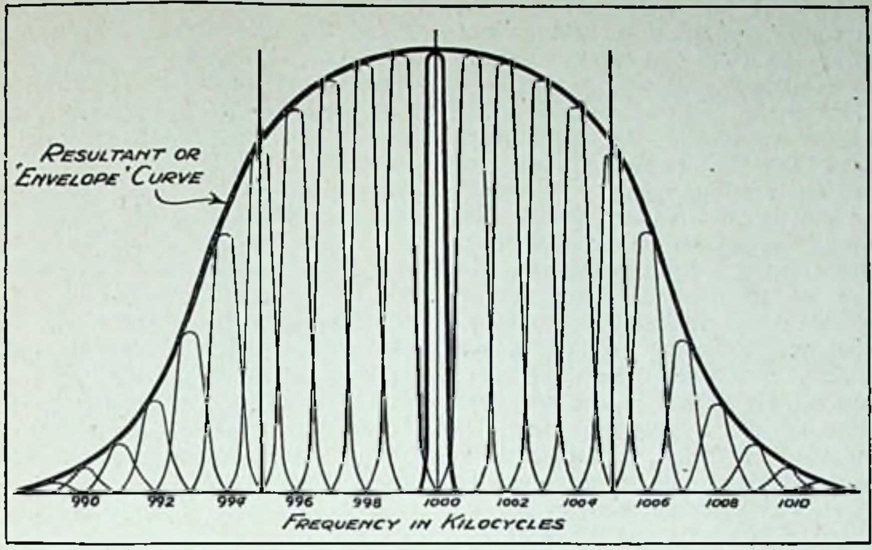


Fig. 3.
A modulated carrier wave. The superimposed speech currents cause sidebands, or additional frequencies, which cause the transmitted energy to be spread over a very wide band of frequencies, or wavelengths.

danger of their causing interference with other stations is slight, unless several stations are crowded together within a restricted area, as is the case, for example, in New York City.

A Cause of Interference.

If stations were separated by only 5 kc. the state of affairs, shown in the form of "envelope" curves, would be as shown in Fig. 4. The "skirts" of the curves overlap, causing interference over the band of frequencies covered by the overlap, and shown shaded in the diagram. When two stations operate on almost the same wavelength, not only do the sideband frequencies overlap, the carrier waves overlap as well. When this happens heterodyning results in the receiver, and this manifests itself as a continuous and steady whistling noise.

Having examined how **present methods of modulation cause broadcasting stations to spread untidily over a wide band of frequencies,** let us see what the effect is at the receiving end.

In these days of overcrowding in the ether it is the aim and object of every receiving enthusiast to make his receiver as selective as possible, so that he can eliminate unwanted signals from stations broadcasting on adjacent frequencies, and enjoy, free from interference, the programme of the station he chooses to listen to.

It is quite possible to construct a receiver which will have a "razor sharp" tuning. The resonance curve of such a receiver would resemble Fig. 2. Interpreting Fig. 2 in terms of reception, the curve indicates that the receiver would extract the maximum amount of energy from passing waves having a frequency of 1,000 kc., or a wavelength of 300 metres. Waves having a frequency slightly above or below 1,000 kc. would cause practically no response in the receiver.

It is evident that such a receiver would be quite useless for broadcast reception, as reference to Fig. 3 will make plain. All frequencies lying outside the immediate vicinity of 1,000 kc. would be entirely lost. In practice this means that such a receiver would be responsible for a painful amount of distortion.

For absolutely perfect reproduction of broadcasting the tuning of the receiver would have to be made very much less sharp, so that it could accept with equal intensity all frequencies lying between 990 and 1,010 kc. Such a receiver, whilst being admirable from the point of view of musical reproduction, would be extremely vulnerable from an interference point of view. As in many other matters it is usual to compromise, and design a receiver which will be fairly selective but yet will accept frequencies over a 10 kc. band, corresponding to the frequency separation of stations.

It will now be apparent that if some *new method of modulation* could be introduced it would not only clear the ether very considerably and make room for a much larger number of stations, it would also put an end to the selectivity versus purity of reproduction problem of set designers, which can be solved at present only by a compromise which is detrimental to both ideals. If broadcasting stations could be confined within a frequency band only a few cycles wide, ultra-selective receivers could be produced which would at the same time give 100 per cent. perfect reproduction.

This is a problem which closely affects television broadcasting as well as sound broadcasting, for in order to broadcast television the microphone of a broadcasting station is replaced by light-sensitive cells, whose amplified output (in the form of varying electric currents similar to speech currents) is caused to modulate the carrier wave.

In our Editorial last month we referred to the system of modulation used in the conduct of the transatlantic wireless telephone service. This system is known as the Single Sideband, Carrier Eliminated System, and was developed by Carson, an engineer of the American Telephone and Telegraph Co., New York. The name of the system suggests the explanation, which is that, in the first place, steps are taken at the transmitter to cancel out the carrier wave, so that only the speech waves are sent out.

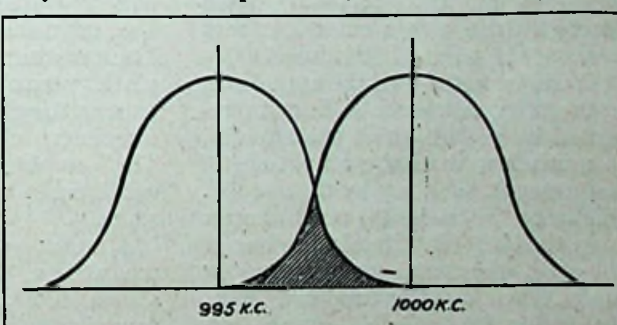


Fig. 4.
The above diagram represents the sideband envelopes of two broadcasting stations separated by 5 kc. instead of 10 kc. The "skirts" of the curves overlap, causing interference over the band of frequencies covered by the shaded portion.

An examination of Fig. 3 will reveal the fact that the curve on the left-hand side of the vertical axis is exactly duplicated on the right-hand side, which suggests that the duplication might be avoided by transmitting one set of curves only. This is exactly what is done, the missing set of sidebands being reproduced again at the receiver. As speech does not cover so wide a frequency band as music, the transatlantic telephone service is carried on on a frequency band only about 3 kc. wide. That is a step in the right direction, but something more is required.

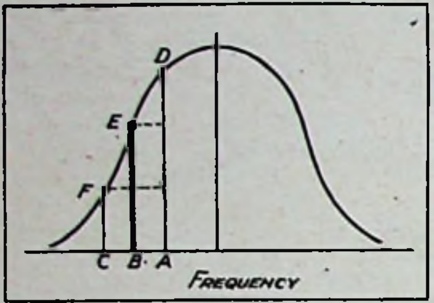


Fig. 5.
Illustrating the effect of frequency modulation.

Another method of modulation, called frequency modulation, was described by Fessenden about thirty years ago. His plan was to cause the speech currents to vary, not the *intensity* of the carrier wave, but the *frequency* of it. The effect is illustrated diagrammatically in Fig. 5, where the resonance curve has been purposely drawn very flat and wide at the skirts in order to make the explanation clear. Variations from the fundamental frequency, caused by frequency modulation, are shown at *A*, *B* and *C*. Verticals drawn through these points cut the carrier wave at the points *D*, *E* and *F*.

It will be noted that the amplitude, or intensity of frequency *E*, as represented by the length of the line *CF*, is much less than the amplitude of frequency *B*, as shown by the line *BE*. Similarly, the line *BE* is much shorter than the line *AD*. Herein lies one of the great disadvantages of frequency modulation by this method, *viz., the higher the applied speech frequency the lower is the intensity of the radiated signal representing that frequency*. In other words, severe distortion is introduced; low notes are loudly reproduced, whilst high notes are very faint or entirely inaudible.

The effect upon the carrier wave, as compared with intensity modulation, is shown in the lower curve of Fig. 1. The method eliminates sideband frequencies, as we know them. Low frequency components must still be present in the carrier wave, of course, but they are not present to anything like the extent they are when present methods are used.

From the point of view of interference elimination, the method cannot be described as ideal, for a broadcasting station using Fessenden's system of modulation would still wander about on either side of its fundamental frequency, due to the fact of modulation being accomplished by a variation of that frequency. Referring to Fig. 2, the effect is as if the carrier wave curve was rapidly shifted to and fro from right to left. However, using frequency modulation, it is possible to transmit speech on a wave which extends only some 100 cycles on either side of its fundamental frequency. Compare this with the 10,000 cycles insisted upon, and required, by present intensity modulation methods.

Referring to Fig. 1, it will be observed that the rise and fall of the low frequency curve (centre curve) coincides with the crowding and spacing of the carrier wave, the latter being crowded where the curve reaches its highest point and widely spaced where it reaches the lowest point.

Methods.

Various methods of carrying out frequency modulation have been tried. The current from the microphone can be applied to vibrate an electromagnet to which is attached one plate of a small tuning condenser connected in parallel with the main aerial tuning condenser. The movement of the condenser plate varies the capacity of the transmitting aerial, and hence the frequency of the radiated wave. The *amplitude* of the generated oscillations remains virtually constant.

Another method of frequency modulation, due to Alexanderson, is shown in Fig. 6. A coil of wire is wound round a closed iron core and connected to the aerial circuit. A second coil carries an energising current, which produces in the iron core an almost saturated magnetic field. In this condition speech currents are caused, by means of a third coil, to vary the magnetic field. Under such circumstances the inductance of the first coil is varied, and as it is connected to the aerial circuit the inductance of the aerial circuit, and hence the radiated frequency is varied. A disadvantage of this method is that distortion is introduced owing to the effects of hysteresis in the iron core.

To review the position. Has frequency modulation any advantages?

Are sidebands present? They are, but not to anything like the extent to which we are accustomed in amplitude modulation. Less room in the ether is thus required.

Sidebands with intensity modulation are of uniform intensity, thus there is no distortion.

Sidebands with frequency modulation become weaker the higher the frequency, thus causing considerable distortion.

Do we want sidebands at all in such a case? The answer is No. All we want is the resonance curve. Cannot some one devise a method of eliminating sidebands entirely, thus leaving us with a resonance curve such as is shown in Fig. 5, the width of which we can then make as narrow as we wish and confine a broadcasting station to a few cycles only.

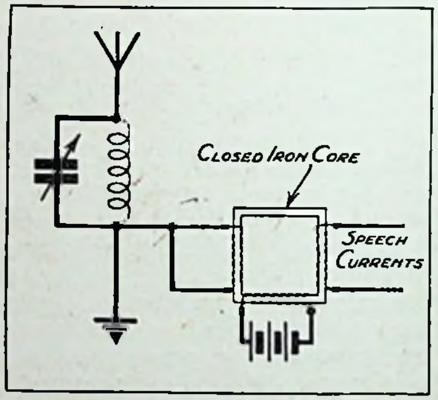


Fig. 6.
Alexanderson's method of frequency modulation.

Having thus enlarged upon one of the themes of our January Editorial, we feel that, in conclusion, we cannot do better than draw attention to one of our Editorial paragraphs, which states:—

> **"When it comes to a discussion of the problems of television we suggest that Captain Eckersley leave entirely alone a subject which is completely outside his sphere, and devote his capable attentions instead to this pressing problem, the solution of which will confer a lasting benefit not only upon himself but also upon his Corporation and the public."**

Sydney A. Moseley says Now then, Capt. Eckersley!

IN my last article I took up the placid and friendly attitude of one who could see the end of the road. After all, the greatest fighters are those who know when the fight is over, and when the time to shake hands has come.

It was my belief, from the knowledge that was in my possession, that the atmosphere of mistrust and misunderstanding which had existed for some considerable time had now been dissipated.

It is in this spirit that I propose to go one step further, and to address myself to the small band of die-hards who have been led, with a persistence worthy of a less worthy cause, by our friend Capt. Eckersley.

A mutual friend has pointed out to me that the impasse which was created through the decision of the B.B.C. in September last was not altogether the fault of the chief engineer. It has been said that as a matter of policy he was opposed to the union of sight and sound.

He preferred to develop broadcasting of music, singing and speech along its own line, and to leave those who wished to broadcast pictures to work out their own destiny.

If that were his considered and conscientious policy, and he had pursued it unflinchingly, and without any suggestions of favouritism, I could have understood him and appreciated his position.

That his position would have been untenable goes without saying, because he must see that it is impossible to stem the progress of television, any more than it is possible to stay the hand of progress itself. But, in giving his acquiescence to the broadcasting of wireless pictures he committed himself to a new policy, which, in my view, rendered his objections to the broadcasting of television illogical.

He may have genuine qualms in believing that in the actual transmission of television he would come up against certain technical problems which would have to be tackled.

He may even believe that such is the case still.

Very well, then.

When the time for experimental broadcasting comes there should be mutual co-operation between Mr. Baird (whom I know—despite what has happened—bears him no malice whatever), Capt. Eckersley, and the staffs of both the B.B.C. and the Baird Company. I have never posed as a technician, but (and this should interest the chief engineer) from information which I have taken care to obtain, I believe that these obstacles can be surmounted.

Comes the question whether television has recently advanced to a stage where it would be of general interest: Let us, for the moment, wash out the past, and come to the latest happenings. I will offer no views, but give the facts.

Within the past few weeks there have trooped up to the Baird Studios in Long Acre such eminent men and women as Sir Thomas Inskip, the Attorney-General, Sir Herbert Samuel (who came twice), Lady Waley Cohen, Field-Marshal Lord Allenby and Lady Allenby, several Members of Parliament, and certain other people of public prestige whose names I am not permitted to mention.

These emissaries merely viewed television from the public standpoint. They came to see whether this thing was as interesting as we claimed it to be. They saw their own friends televised, they saw the pictures of magazine covers flashed *instantaneously*, and read the names on the outside cover of a music sheet.

There can be no gainsaying they were "held."

From their spoken and written observations they were almost unanimous in stating that the images were easily recognisable and were of astonishing interest. They were puzzled, as I have been all along, as to why we were not permitted to broadcast television to the multitude.

Now I put it to Capt. Eckersley, in as fair a manner as I am capable of (labouring under a sense of partisanship, which I have never striven to hide): Here is a science

[Photo by courtesy of G.E.C.

A PHOTO-ELECTRIC PHOTOMETER. (Employing Osram Photo-Cell.)

A photometer for measuring the performance of lamps in which a photo-electric cell takes the place of the human eye. Measurements can be quickly made by a single operator to an accuracy of —1/4 in lumens; such accuracy has hitherto only been attained by averaging the results of several highly skilled observers. This apparatus was shown at the Physical and Optical Society Exhibition, Kensington.

that has progressed out of all recognition. Here is an invention by a Britisher, who has, despite his limited resources, contrived to keep ahead of foreign rivals with immense resources in their power.

Apart from this, we have had the French and German experts over to judge what has been done. Let me quote the dispatch from a newspaper, the original of which I took the trouble to see:

"I called to-day upon Dr. Bredow, who occupies in Germany a position similar to that of Sir John Reith, the Director-General of the B.B.C., and who is also a member of the Government.

"Dr. Bredow and his two chief engineers, Dr. Reisser and Dr. Baneth, have only recently returned from London, where they made a close examination of the Baird Television System in its present stage of development.

"I found Dr. Bredow firmer than ever in his belief of the possibilities of this system.

"He declared that he and his colleagues had been *amazed* (the German word he used was even more emphatic, but has no English equivalent) by what they had been allowed to see in the Baird laboratories."

From the progress which television has made, and which is beyond dispute, it is evident that with sympathy and help, particularly from such a powerful body as the B.B.C., this British invention will forge ahead even more rapidly.

Isn't it the very least one would expect from the B.B.C., which possesses the facilities, to say to this inventor: "There may be technical difficulties, but we don't wish to hinder you; on the contrary we wish to help you. Let us come together, and see what we can do to help. We will, without any undue interference with our present work, grant you such facilities as will enable you to justify your claims. We will give you so fair a trial that not even our bitterest enemies will be able to point a finger at us and declare that we have not played the game. We will shatter with one gesture the whole atmosphere of suspicion that has been bred in the city by malcontents."

Again, obliterating what has happened in the past, I put it to the B.B.C. that the time has now come to make a gesture worthy of its reputation, power and good name.

I will stake my reputation that if Capt. Eckersley begins to help in the broadcasting of Mr. Baird's television he will soon become immersed in this wonderful new branch of wireless, and will be lending his whole-hearted co-operation. He will say that the faith of those who believed in this thing had some foundation in fact, and beyond that he will have an opportunity of making up for the extreme caution he has adopted in the past.

Before and after Television

RADIO WOOER: "You used to be the apple of my eye, sweetheart; and now you are the flicker of my neon tube."
—*Radio News*.

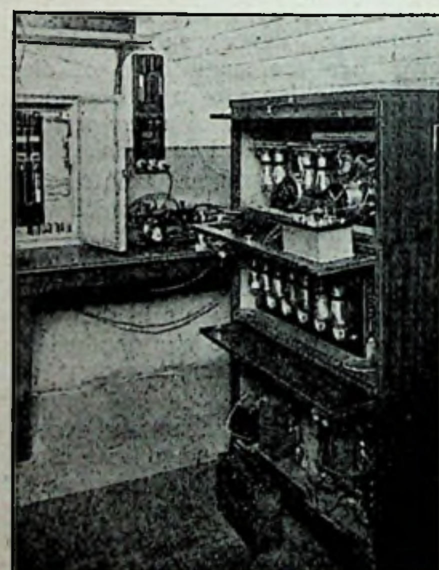
Those Television Nights!

JIGGS: "I'm stayin' in to-night, Maggie."
MAGGIE: "No, you're going out. Don't I know those bathing beauties from Atlantic City are going to be on the radio?"
—*Radio News*.

Why They Make Hair Dye

LEGMAN: "What's wrong with the Radio Editor now?"

CUB: "Some bird wrote in and wanted to know if he could pick up movies of the football games if he bought a screen-grid tube for his radio!"—*Radio News*.



(*Photo by courtesy of Marconi's Wireless Tel. Co.*)

Arrangement of synchronising fork used in Transatlantic facsimile telegraphy work.

The Story of Chemistry

Part V

Chemical Families

By W. F. F. SHEARCROFT, B.Sc., A.I.C.

WE have seen, in previous articles of this series, that matter in all its forms is made up of remarkably tiny particles, called molecules. The molecules, in their turn, are made up of still smaller particles, the atoms. The make-up of the molecule is not a haphazard affair, but follows more or less well-defined plans. All molecules built up on any one plan show certain definite resemblances, and so the specimens of matter which they compose will have similar properties.

Hence we are able to group the many different substances which we meet in the universe into a comparatively few classes, and thus chemistry becomes something intelligible, instead of a mass of unrelated facts. We can now turn our attention to some of the more important chemical families, and learn what to expect of them as members of a family.

Our first consideration is more a tribe than a family. All substances are either elements or compounds and we have already defined the difference between these two classes. The difference can be traced to a difference of molecular structure, all the elementary molecules having but one kind of atom in them, while those of the compounds have at least more than one, and may have a number of different kinds.

Metals and Non-Metals.

Among the elements we distinguish two large classes—the *metals* and the *non-metals*. It is an everyday classification over which we are never likely to make a mistake. We all recognise such elements as gold, silver, copper, iron or lead as metals, while sulphur, oxygen, phosphorus are common examples of the non-metallic elements. The metals we pick out as being characterised by their lustre, high melting-point, and opacity. Most of them are *ductile*, that is, can be drawn out into fine wire. Most of them are *malleable*, which means that they can be hammered out into thin plates. They are also good conductors of electricity and heat. The common uses of metals in everyday life afford instances of these properties.

Physical Properties.

Such properties as those enumerated above are called *physical* properties, and we can at once think of exceptions. Thus mercury is liquid at ordinary temperatures. Graphite, which is a non-metal, is a good conductor, and there are numerous compounds which look like metals. Dealing with an unknown substance, we should not be prepared to place it in the class of metals by an examination of its physical properties only. This division is really a chemical matter, and it is to chemical properties we must turn. Here, however, we do not find any very definite help.

The elements, with some exceptions to be noted later, enter into chemical combination with oxygen, forming compounds known as *oxides*. In most cases this can be effected by simply heating the element in air or oxygen. Usually the process we call burning takes place with the formation of the oxide. Thus, for example, a piece of magnesium burns with a very bright light forming a white powder which is magnesium oxide. Sulphur burns with a blue flame, giving a gas with a characteristic odour, known as sulphur dioxide. Sodium, a very typical example of a metal, burns to give a powder, sodium oxide, and so on. These particular actions have been studied, and we know the molecular composition of the products formed, and, using the usual conventions, can write equations for the reactions thus:—

$$2\,Mg + O_2 \longrightarrow 2\,MgO$$
$$S + O_2 \longrightarrow SO_2$$
$$4\,Na + O_2 \longrightarrow 2\,Na_2O.$$

We can write a general formula for oxides thus: $E.O$, where E stands for atoms of any element.

It will be obvious that these oxides are important substances. Many of them have practical applications of immense importance. An examination of them leads to a general classification. Taking sulphur oxide as a typical example of the oxide of a non-metal, we find that it will dissolve in water, and that the solution we get is an acid. Here by mixing an oxide and water we get an acid, that is, a chemical action has taken place which may be represented by the equation—

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

Acidic Oxides.

The acid (H_2SO_3) is called sulphurous acid. Now, further research has shown that this is a chemical property of all typical oxides of non-metals, and for this reason they are called *acidic oxides*, which must not be interpreted to mean that the oxide itself is an acid.

If now we repeat this experiment with sodium oxide we find that it also enters into a chemical action with water, but does not produce an acid. If we add a little of the sodium oxide powder to water, we obtain a solution which has a caustic taste, which turns red litmus blue (which is just the opposite to the action of an acid) and the solution has a soapy feel.

This substance belongs to a class of substances called *bases*. We shall have more to say about bases later, but for the moment they may be regarded as more or less the opposites of an acid. Further experiment shows us that the oxides of all typical metals will react with water to produce bases. Sometimes the reaction is brought about by simply mixing the two together; in other cases more complicated means are necessary. Such oxides are called *basic oxides*.

Characteristics of Non-Metals.

Here, then, we have a chemical distinction between metals and non-metals, in the same way as we have a physical distinction, for in general the non-metals do not have a metallic lustre, have low melting points, and are transparent. They are brittle and so cannot be drawn into wires or beaten into plates, and they are bad conductors of electricity and heat. Again, there are exceptions.

The chemical distinction is a surer test as to which of these two classes an element should be placed in, than the physical distinctions. However, the chemical test is not unfailing, because there are elements which have more than one oxide. This can easily be so, as it is possible to form a limitless number of different compounds by joining up atoms of oxygen with atoms of one element. In any case the actual number which exist is always a small number. Thus, for example, sulphur forms another oxide called sulphur trioxide which has the formula (SO_3). This also is an acidic oxide, forming sulphuric acid (H_2SO_4) with water.

$$SO_3+H_2O \longrightarrow H_2SO_4$$

Certain elements form two classes of oxides. Thus the element chromium has one oxide known as chromous oxide which is a typical basic oxide, on the strength of which chromium would be classed as a metal. It also has another oxide, chromium trioxide, which is acidic, and which would place the element in the class of non-metals. There is a further complication in that some elements have oxides which can be either acidic or basic according to the circumstances in which they find themselves. Thus arsenic has such an oxide, from which can be derived both an acid and a base.

It was the fashion at one time to class the elements which did not seem certain as to which class they belonged to as a little group unto themselves, but a truer aspect of the case is to consider that we can write a list of the elements in such an order that, at one end we have those which are most metallic, and at the other end we have those which are most non-metallic, and through the series we get a gradual transition, with no real break anywhere.

We cannot draw a picture of the molecules of the elements, for in the majority of cases we do not know how many atoms they contain. Some elements exist in a number of modifications which are known as *allotropic modifications*. Thus, a diamond, which sparkles on a countess's tiara, and the graphite or blacklead, with which her maid cleans the grate, are one and the same thing chemically. Both are forms of the substance carbon, a non-metallic element, and we imagine that the only difference is that the diamond molecule contains a different number of carbon atoms than the molecule of graphite. Possibly the arrangement is different too.

THIS is the fifth of our contributor's articles on the story of chemistry, written in simple language, with the introduction only of those chemical formulæ as are essential to an understanding of the subject. Last month he dealt with the architecture of the molecule. This month he deals with the composition of metals and non-metals, and, coming to a consideration of compounds, with oxides in their various forms.

Sulphur is another example of an element existing in more than one form. We are all familiar with the roll-sulphur sold by the druggist. It is a mass of broken crystals, which are transparent when separated from one another, and from their geometric form are known as rhombic sulphur. Sulphur can also exist in a form that looks and feels like elastic. If roll-sulphur be melted and raised almost to its boiling point we get a black liquid. If this is poured into cold water we get a sample of the elastic form of sulphur, which is called plastic sulphur. Many other quite distinct forms of sulphur are known. Selenium is another example well known to readers of TELEVISION.

The elements also group themselves into more closely related families of a few elements each. This grouping is rather a wonderful business, which can possibly receive consideration at some future time. Every element in a family shows certain resemblances to every other member of the family. A well-known example is the group of metals known as the *Alkali Metals*, of which sodium and potassium are typical members, and rubidium, cæsium and lithium complete the family. They are all very light, soft metals, which react violently with water, and again they will be familiar to readers of this journal.

So much then for the present as to the elements—the fundamental point to remember about a typical metal, or shall we say an element acting as a typical metal, is that the oxide it forms reacts with water to produce a base, while the non-metallic element has an oxide which will produce an acid with water.

When passing from the elements to compounds we shall, for the purposes of these articles, have to confine our attention to a few of the more important classes. First among these we may place *Oxides*, the compounds formed when elements combine with oxygen. We have already seen that they serve to divide the elements into two classes, according as the oxides are acidic or basic.

Importance of Oxygen.

Practically all the elements unite with oxygen. No oxides are known of the elements fluorine or bromine, but there does not appear to be any particular reason for these exceptions. Perhaps we have not discovered the conditions necessary for the union or the conditions necessary for maintaining these oxides in existence. Another small group of elements, the *inert gases*, which contains helium, argon, neon, krypton, and xenon, also have no oxides. In this case a reasonable theoretical explanation has been suggested for the peculiarity. The rest of the elements form one or more oxides. Some of these oxides

(*Continued on page* 45.)

The Carbon Arc

By H. WOLFSON

In the following article our contributor gives some useful constructional information on a type of carbon arc which will prove useful to television experimenters who want a powerful and economical source of light. Apart from its value to experimenters, it has other uses, which are detailed in the course of the article.

MANY of my experimentally minded readers have no doubt wished that they could obtain a more powerful illumination of the object at their television transmitter, without going to the expense of commercially made arc lamps, whether of the carbon type or the mercury vapour type.

In this article I shall endeavour to explain how anyone who has electric light fitted in his home can make a carbon arc lamp which is rich in rays of the visible spectrum, and in addition contains about 5 per cent. of ultra-violet light. For this reason the lamp can be used at home as an artificial sunbath, without the risk which attends the private use of mercury arc lamps.

With its aid the experimenter will be able to carry out research into the subject of photo-electricity, where a powerful source of light is essential. In a later article I shall describe how one may fit up the lamp so as to obtain a spectrum measuring about 7 centimetres in length, so that it is possible to investigate the colour-sensitiveness of light-sensitive and photo-electric devices.

Materials Required.

The materials required in the construction of the carbon arc are as follows: One aluminium bowl, hemispherical in shape, and 10 or 12 inches in diameter. One heating element for G.E.C. bowl fire; this should be of 750 watts consumption, and suitable for the particular voltage of your supply. The G.E.C. catalogue number of this element, which costs 5s., is D 3751. The reason why I am stressing the make of heater element is that the size and shape of the G.E.C. one is the most suitable I have come across for the purpose in view.

Next we require a combined switch and plug, 5 amp. type, of any good make, and preferably fitted with bakelite cap and dolly. The remaining materials are usually to be found in any amateur's workshop, these being short lengths of brass and ebonite tube.

The general layout of the apparatus is shown in Fig. 1, and this should be studied carefully before proceeding with the construction. *H* is the heater, which is fitted just within the bowl, so as to be quite clear of the carbons, marked *C* in the diagram. The carbons are held in two brass tubes, which serve as conductors to connect the carbons with the source of electric supply. It is, of course, necessary to insulate the brass holders both from one another and from the bowl, so that the instrument will be perfectly safe in operation.

The brass tube for holding the carbons should first be obtained. This has an internal diameter of 8 millimetres, or $\frac{3}{10}$ inch, and we require two pieces each 6 inches long. The other two pieces of brass tubing should be $1\frac{1}{2}$ inches in length, and of such an internal diameter that the carbon holders will just slide tightly through them. In the one which I have constructed the internal diameter of these sleeves is $\frac{3}{8}$ inch.

The brass sleeves must be covered

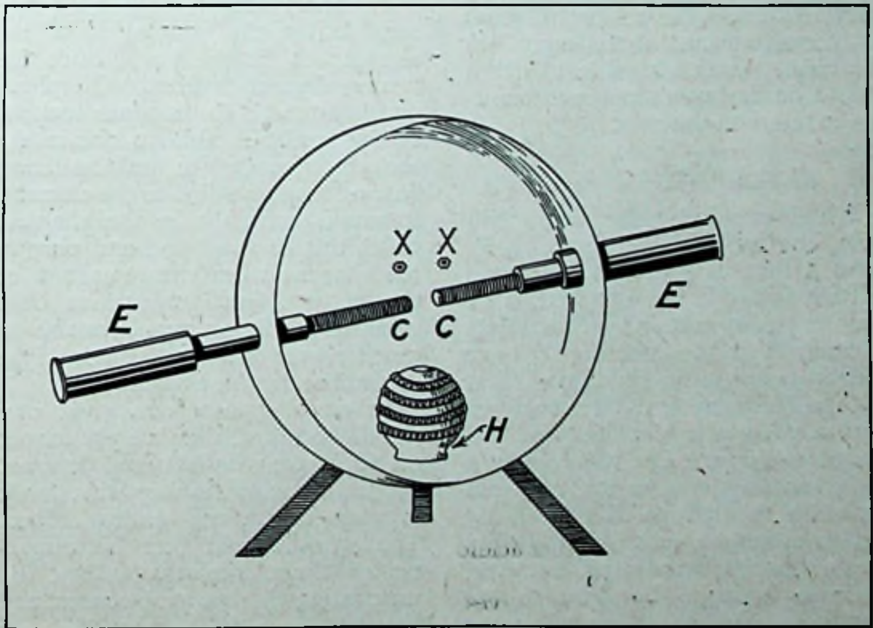


Fig. 1.
Illustrating the finished instrument. *H* is the heater element. *CC* are carbons. *XX* are nuts securing the switch plug to back of bowl. *EE* are ebonite handles.

with some form of insulating tubing. I used ebonite, though micanite or some similar material which is unaffected by heat is to be preferred. This ebonite bushing was of ½ inch internal and ¾ inch external diameter. Two pieces, 1¾ inches long, should be cut off.

Fig. 2. Actual size of nut used for threading ebonite bushes. Note the four cuts in the thread of the nut, which can be used as a die.

We can now start to drill the bowl for the insulating bushes. With a centre punch make two marks on the bowl at opposite ends of a diameter, and about 1¼ inches from the edge of the bowl. These should now be drilled so as to accommodate the ebonite or other insulating bushes. If a ¾ inch drill is not available, one should drill the largest hole possible and then enlarge this with any sharp tool. This should present little or no difficulty, as aluminium is sufficiently soft to be cut with a penknife. The hole should just accommodate the bush tightly, and the next step is to secure the bush to the bowl. This is best accomplished by using iron or brass nuts, of such a size as to screw on to the ebonite tube. These nuts should be cut with what is known as a gas thread, as this does not necessitate cutting so deeply into the bush. It is advisable to cut a thread on the bushes before attempting to screw on the nuts.

A Suitable Die.

If a die of suitable size is not available, one can be made quite easily from a nut, as great accuracy and cutting power is not required, since ebonite is very soft. One of the nuts which will fit the tube should have four cuts made on its thread, first with a hacksaw, and then enlarged with a triangular file. This is illustrated in Fig. 2. The tube can now be threaded quite easily, and can then be secured to the bowl by fitting a nut at each side. Before assembling the apparatus, however, there is more to be done to the bushes. The two brass sleeves should be forced inside the ebonite bushes, so that there is an overlap at each end of ⅛ inch of ebonite.

The bush and sleeve is now placed in a vice and a hole drilled as shown in Fig. 3, ½ inch from one end. The size of this hole should be either 4 BA or 6 BA tap. The hole is then threaded with the appropriate tap. It should be noted that the hole is drilled through both the ebonite and one thickness of brass. A brass bolt fitted with two nuts or two washers is then screwed into the hole, and its length so adjusted by filing that there is little or no projection inside the sleeve, which would, of course, interfere with the sliding motion of the carbon holders.

Two holes should next be drilled in the back of the bowl, marked in Fig. 1 as *XX*, at such a distance apart as to accommodate nuts and bolts to fix the switch plug on the *outside* of the aluminium bowl. In my model, using a G.E.C. switch plug, the distance between these holes is 1½ inches.

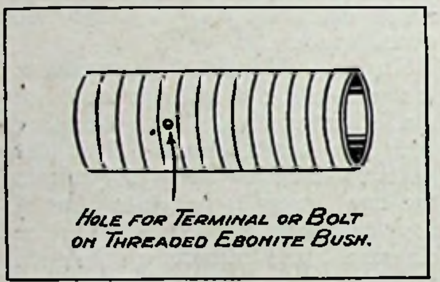


Fig. 3.
Actual size of ebonite bush.

The most difficult part of the construction is the adaptation of the element to fit the bowl, since the heater element is fitted with plugs, and is intended to plug into sockets. If the reader is able to obtain the sockets mounted in an insulating base at the same time as the element, it would certainly be the simplest to fit this to the bowl, and plug in the element when the remainder of the constructional work has been completed. Being myself unable to procure such sockets, I made slight alterations in the element itself.

In carrying these out, great care should be taken, that the pot former on which the wire is wound does not become damaged in any way, for it is very brittle and easily broken. The wires should first be disconnected from the two plugs, by unscrewing the two grub-screws, and the pot base itself may then be removed by unscrewing the three nuts which secure it to the body of the element. It is then a simple matter to remove the plugs, by unscrewing the screws at the back of the base.

The base is now replaced, and the two ends of the heater wire are brought through the two holes in the base. Be careful you do not lose the little insulating beads. This is best guarded against by turning the ends of the wire into closed loops while working with the element.

Fitting the Heater Element.

The three nuts holding the base having been tightened, the next thing is to make a template, by pressing the three projecting pieces of brass rod which secures the base to the rest of the element on to a piece of paper. By means of this template, holes are drilled in the bowl to take the element. Reference to Fig. 1 will show you the position of the heater element, which needs only to be approximate. In my own case the distance of the two front holes from the edge of the bowl is about 1½ inches, and the remaining hole is about 3 inches from the edge. Two large holes should be made within the triangle formed by these other holes, through which the wires from the heater will pass. Reference to Fig. 4 will make clearer the positions of the holes to be drilled.

The assembling of the apparatus is the next step to be taken. The heater should first be fitted with two long copper wires, say, 18 inches

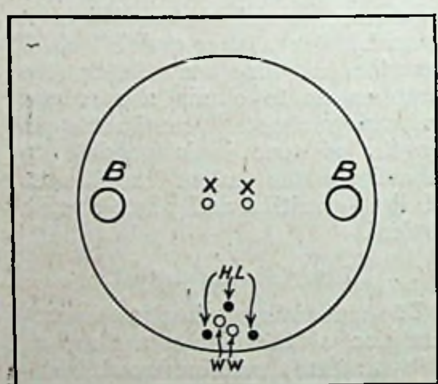


Fig. 4.
XX Holes in centre back to secure switch plug. *BB* Holes for bushes. *HL* Heater legs. *WW* Large holes for wires from heater.

long, by the use of small copper or brass connectors. It is, of course, impracticable to solder or twist together the heater wire to the connecting wire. These little connectors can be obtained at any wireless shop, and are illustrated in Fig. 5. They are of such a size that they can be neatly tucked away in the holes in the pot base of the heater Fig. 5B.

You will need about a gross of small

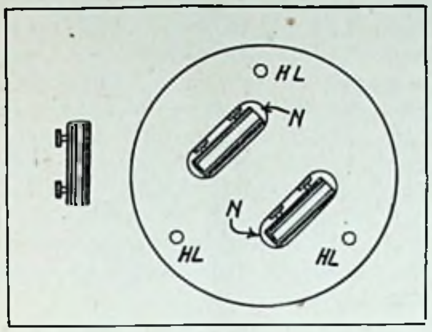


Fig. 5.
Shows connector which joins heater wire to copper connecting wire, and (b) pot base of heater with projecting brass rods *HL* used for securing to bowl. The connector is wedged in holes *NN*.

black insulating beads, sometimes called fish-spine beads. These should be slipped on to *all bare wires*, so as to completely cover them, before any connections are made. The theoretical diagram (Fig. 6) shows exactly how the connections should be made, but so that there shall be no mistakes, I will give a point-to-point list. Follow this out several times on the theoretical diagram and then on Fig. 1 until you are fully conversant with the idea before you begin to do the actual connections, and be sure to check the wiring over before you start to use the apparatus. It is much more important to get the wiring correct in an instrument which is to be connected to the electric supply mains, than in an ordinary wireless set.

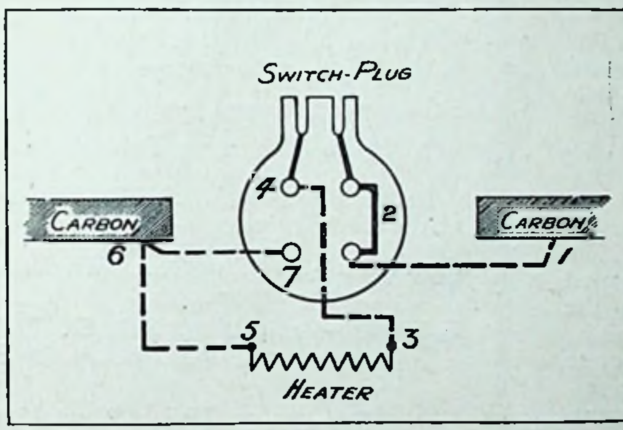


Fig. 6.
Theoretical diagram showing connections in dotted lines.

Point-to-point connections: One carbon holder to bonded contact in switch plug (1–2); one side of heater (3) to contact connected to the socket in the switch plug (4) opposite the bonded contacts (see Fig. 6); other side of heater (5) to other carbon holder (6) and without breaking the wire to remaining contact in switch plug (7).

The finishing touches can now be put to our artificial sunbath, or carbon arc. The two carbon holders should have one end of each opened out slightly to take 8 mm. carbons, which should be cored, and this prevents the holders slipping out of the instrument. Two large ebonite handles must be fitted on to the extreme ends of the holders, as shown in Fig. 1. The internal diameter of the tubing for the handles is chosen so as to fit tightly on to the holders, and in my case is 7/20 inch.

The plug which is supplied with the switch is fastened to one end of a piece of twin flex, and the other end is fitted with either a lampholder adaptor or with a plug to fit a heater socket, the choice of these two depending on your house wiring, and as to whether you propose running the apparatus off the lighting or power circuit.

A Conversion Switch.

The idea of the switch plug at the back of the instrument is not only to serve as a reliable means of connecting to the supply mains, but also to convert the apparatus at will into either a carbon arc sunbath or an electric fire. When the switch is closed, the apparatus acts as a fire and consumes three-quarters of a unit per hour, and with the switch open the arc is brought into circuit, and the consumption of electricity is somewhat *less* than this figure.

Note that the switch does not isolate the apparatus from the mains, and it is thus necessary to remove the plug from the back when not in use.

"Wear Your Goggles."

Now as to the operation of the carbon arc. First provide yourself with a pair of dark coloured goggles, preferably fitted with cobalt blue glass. It is *most important* that you (and everyone who is looking on) should wear these goggles all the time that the arc is burning, otherwise *permanent injury* to the eyes might result, and in any case a severe attack of conjunctivitis would result from exposure of the unprotected eye to the ultra-violet rays of the lamp. You would do well to hang a card near the apparatus, or to paint inside the bowl the words "**Wear your goggles**" as a permanent reminder.

Having made sure that the switch at the back of the apparatus is open, the carbons, which should have been placed in the holders, are brought together and then rapidly separated by a small distance, say, ⅛ inch. A brilliant arc is immediately struck, and will continue to burn steadily, with slight adjustment from time to time, if the distance between the carbons is kept about ¼ inch.

If desired to use the apparatus as an electric fire, it is only necessary to turn the switch at the back to the closed position. The current consumption of the instrument being in the neighbourhood of 4 or 5 amps., it is essential that the fuse controlling the point from which the supply of current is taken is designed to take this current. To those who desire additional control of the arc system I would advise the installation of a separate switch and fuse, in the room which is set apart for experiments of this nature.

This need not present any difficulties, and a few hints may be of use to my readers. Two porcelain fuses and a switch should be fastened to a baseboard, and wired as shown in Fig. 7. The one end is connected to the mains via a lampholder or power plug, while the other side is connected to a

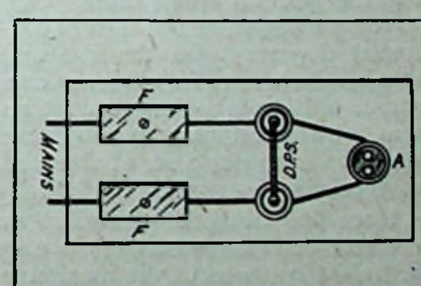


Fig. 7.
FF are fuses. *DPS* is a double-pole switch and *A* is socket for plug.

socket to accommodate the plug or adaptor which is fitted on to the flexible lead attached to the carbon arc. For all those who are carrying out experiments involving the use of the electric mains, I would suggest the fitting of this separate control device, by means of which much of the trouble caused by blown fuses can be obviated.

Before concluding, a few words concerning the theory of the arc and the reasons for the design of the lamp which has just been described will not be out of place.

Theory of the Arc.

When two rods of carbon are connected to a source of electric energy, such that a potential difference of at least 30 volts exists, an arc passes between the rods when they are slightly separated. The arc has a considerable resistance, so that much heat is generated locally, with the result that the very high temperature volatilises the carbon. The carbon vapour thus formed makes the space between the rods conducting, and the flame of burning vapour continues as long as the distance between the rods is not too great. The temperature of the arc is in the region of 3,500° C.

The carbons wear away in course of time, partly owing to the oxidation of the vapour to carbon dioxide, and partly due to an attempted transference from one rod to the other. In the case of an arc running on direct current this is made quite evident, since the positive rod wears away twice as quickly as the negative one, this latter having received some of the carbon transferred from the positive electrode.

Potential Difference Required.

The potential difference required by the carbon arc varies from 30 to 70 volts, while the current consumed depends upon the size and type of the lamp. Its efficiency as a source of light is much greater than that of the ordinary incandescent lamp, fully 10 per cent. of the total energy being converted into light.

Since the potential difference or the voltage of most supplies is considerably in excess of the maximum voltage required by the arc, some means has to be found of reducing the voltage to suitable value. In the case of alternating current this could be done, practically with no loss of energy, by means of a transformer, but since it is not possible to employ a static transformer in the reduction of voltage of direct current, the more wasteful but primarily cheaper method of employing resistance must be resorted to.

This has the additional merit that it can be applied for the same purpose to alternating current, thus making one type of arc "universal," irrespective of the nature of the supply, whether A.C. or D.C. If in use as a sunbath, the subject receives radiant heat treatment at the same time as ultra-violet irradiation. When used in this connection, the patient should be wearing goggles, and facing the lamp at a distance of 2 feet. Ten or fifteen minutes' exposure to the lamp daily will be found to have extremely beneficial effects, so that those of my readers who construct the lamp will have more than ample repayment for their trouble, in this "versatile" little instrument.

Finally, always use metal-cored carbons, which can be obtained from any reputable scientific suppliers. Should anyone experience any difficulty, either in obtaining parts for the lamp or with its construction, I shall be pleased to answer queries addressed to me care of this magazine.

Forthcoming Lectures on Television.

During the month of February the following lectures on television will be given by Mr. J. J. Denton, A.M.I.E.E., Joint Hon. Secretary of the Television Society:—

Feb. 4th.—Technical Institute, Tunbridge Wells, at 7 p.m.

Feb. 14th.—Kensington Radio Society, London, at 7.30 p.m.

Mr. A. Dinsdale, A.M.I.R.E., Editor of TELEVISION, will lecture at the following places:—

Jan. 31st.—St. Polius Room, Windermere, at 3.15 p.m., before the Lecture Association.

Feb. 4th.—Agricultural Hall, St. Mark's Road, Jersey (Channel Isles), at 7.45 p.m., before the St. Helier's Church Literary Society.

Feb. 5th.—Central Hall, Clifton, Guernsey (Channel Isles), at 8 p.m., before the Lecture Society.

Feb. 9th.—Rose Hill School, Banstead, Surrey, at 5.30 p.m.

Feb. 18th.—Town Circus, Blackpool, at 7.30 p.m., before the Co-operative Society.

Feb. 22nd.—Stockwell College (Women's), Stockwell Road, S.W. 9, at 8.30 p.m.

Feb. 24th.—Stoll Theatre, Westgate Road, Newcastle-on-Tyne, at 7 p.m., before the Tyneside Sunday Lecture Society.

Feb. 25th.—Bolber Hall, Westgate Road, Newcastle-on-Tyne, at 7.30 p.m., before the Literary and Philosophical Society.

Feb. 26th.—U.F. Assembly Hall, Moind Place, Edinburgh, at 8 p.m., before the Philosophical Institution.

Feb. 27th.—Chambers Town Hall, Chambers Institution, Peebles, at 8 p.m., before the Tweeddale Society.

March 1st.—Town Hall, Inverness, at 8 p.m.

March 4th.—Sixty Club, Bowden, Cheshire.

March 6th.—Harrowgate Literary Society.

All these lectures will be illustrated with lantern slides and simple experiments.

PROGRESS IN INSTRUMENT DESIGN AND NEW APPARATUS

THE nineteenth annual exhibition of instruments arranged by the physical and optical societies at the Imperial College of Science, London, was held on January 8th, 9th and 10th, 1929.

The exhibits, as in previous years, were arranged in two sections: a "trade section," to which various leading instrument firms contribute, and a "research section," supported by our Government departments, private individuals, and firms engaged on special research.

One very noticeable feature was the increasing number of exhibits incorporating some form of light sensitive device, and attention in this review of the exhibition will be concentrated on these particular exhibits.

Several different types of photo-electric cells, manufactured in America under the trade mark "G–M Visitron," were seen on the stand of Messrs. W. Edwards and Co., the agents for these cells in this country. No technical data was displayed, and further enquiry by the writer has not so far elicited sufficient details to enable one to form an opinion as to the merits of the cells.

An extremely useful little device recently put on the market by Mullards, and known as the "P.M. Potential Divider," attracted my attention. In television experiments one frequently wants a reliable resistance, preferably wire-wound, of a few hundred ohms or thereabouts. The Mullard product is designed to enable several different values of high-tension to be obtained from a supply of D.C. at one voltage. The resistances are wire-wound and there are ten tappings provided, giving resistances ranging from a few hundred to 5,000 ohms. The elements are enclosed in a vacuum tube about the size of an ordinary valve, and it is claimed that they will not unreasonably overheat when used for the purpose for which they were designed.

[Photo by courtesy of G.E.C.

PHOTO-ELECTRIC SET. (Employing Osram Photo-Cell.)

This is a self-contained set, working entirely from A.C. mains. The whole outfit is contained in the box in the foreground. It is designed to be used for any industrial purpose in which a change of light occurs. For instance, in the case shown, a beam of light is focused on the opening in front of it, and every interruption is shown on the counter on the wall above. Thus every person passing in front of the apparatus is counted. Other applications were shown, including the automatic lighting and extinguishing of street lamps.

Messrs. H. W. Sullivan showed selenium cells of extremely low and constant resistance as used in submarine telegraphy.

The Stroboscopic method of measuring rotational speed is not unfamiliar perhaps to some of my readers. The "Strobometer," a special instrument for measuring the percentage slip of induction motors by utilising the principle of the stroboscope, where a steady image is obtained in conjunction with a neon lamp, was an interesting exhibit on the stand of Messrs. H. Tinsley and Co. The instrument is designed so that the percentage slip comes out directly on a scale without further calculation.

The above-mentioned exhibits were all found under the "trade section" of the exhibition.

In the "research section" numerous applications of photo-electric cells formed a prominent feature of the G.E.C. Research Laboratories exhibit. The self-contained set, shown in the circuit diagram of connections, is designed to work entirely from 220 A.C. mains. It is connected thereto by a single pair of leads and consumes about 60 watts. This set works a relay and lights a lamp when the illumination passes through the critical valve, and in spite of the great variability of the supply voltage it is claimed that the critical valve does not change by more than 10 per cent. The set, being self-contained, is intended for industrial use, when automatic control of any mechanism by means of a change from light to darkness is required, and it was shown in operation with a clock-counting mechanism, the pointer going one step forward each time an opaque object (such as a hand) was passed through the light beam.

The detection of dust or smoke either in air or gases was the subject of the following exhibit, also from the same laboratories.

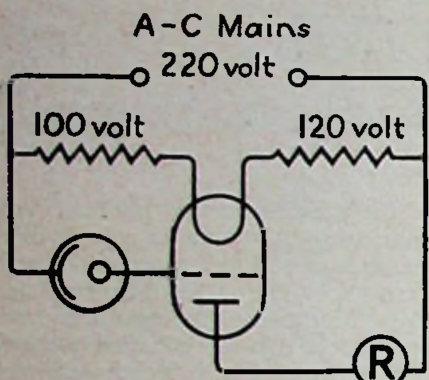


Diagram of connections to G.E.Co's Self-contained Photo-electric set

A beam of light is passed through the air and viewed sideways by the photo-electrical cell. The cell receives no light unless the air contains scattering particles. The circuit is again essentially similar to that shown in the circuit diagram; but since the illumination of the cell is much less, the frequency of intermittence of the light is also much less, and consequently a very slowly acting relay has to be used. It consists of a lever just unbalanced about a pivot slightly inclined to the vertical. Its acceleration, and therefore its initial velocity, is so small that it is held back by the intermittent impulses passed through a magnet, even when these occur only a few times a second. If the impulses cease the lever swings slowly round, completes a circuit and rings a bell. The apparatus was designed primarily to indicate any failure in a plant for purifying blast-furnace gas, but can, of course, be used for any similar purpose.

The British Research Association for the Woollen and Worsted Industries displayed a photo-electric yarn levelness tester.

A Photo-Electric Yarn Tester.

The quality of a finished fabric depends largely on the levelness of the yarn used. In the instrument shown the yarn is drawn continuously across a beam of light so that at any instant an image of a short length can be focussed on the plane of an adjustable slit. The transmitted light falls on a photo-electric cell and the current produced is measured by means of a Lindemann electrometer across a high resistance in conjunction with a projection microscope and curve tracer. The variation of the photo-electric current is a measure of the variation in diameter of the yarn.

Mr. G. P. Barnard, of the National Physical Laboratory, gave demonstrations of the properties of selenium cells by exposing a cell to the intermittent illumination of five different acoustical frequencies in the manner about to be described.

The light from a 1,000-watt gas-filled lamp is interrupted by a large perforated metal disc (2 feet in diameter), driven by a small D.C. motor. Circular holes, $\frac{3}{4}$ inch in diameter, are drilled in the disc as follows: Five concentric circles of radii $3\frac{3}{8}$ inches, $5\frac{1}{8}$ inches, $6\frac{7}{8}$ inches, $8\frac{5}{8}$ inches, $10\frac{3}{8}$ inches respectively are ruled on the disc. At equidistant distances along the circumferences of the five circles 15, 16, 18, 20, 21 holes respectively are drilled. The ratios of the numbers of these holes correspond to the frequency ratios of the following notes in the natural diatonic scale—viz., E, F, G, A, B flat. A wooden shutter is set up close behind the metal disc, so that a selenium cell can be conveniently moved on to any of the five circles of holes.

Fournier d'Albe Type Cell.

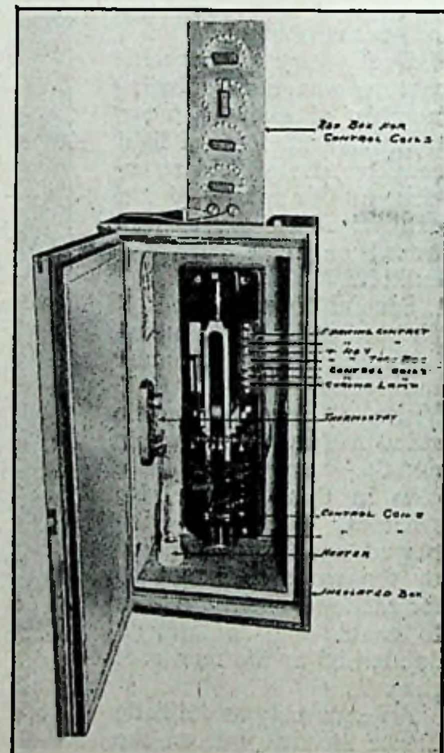
A Fournier d'Albe type selenium cell, having a light-senstive area of approximately $\frac{3}{4}$ inch by $\frac{3}{4}$ inch., is connected in series with a 50-volt battery to the primary of an inter-valve transformer, the secondary of which is connected to the input circuit of the detector valve of a two-stage resistance capacity coupled amplifier. A large loud-speaker is placed in the plate circuit of the last valve.

The fluctuations in current through the cell, after amplification, produce corresponding notes in the loud-speaker. The first part of the "National Anthem" and "There's no place like home" were demonstrated with some measure of success.

In conclusion, I might add that the catalogue, a volume of some 150 pages, was arranged as in previous years on an alphabetical classification of exhibitor's names. This makes it a somewhat tedious business in going round the various exhibits and at the same time trying to find the description of an exhibitor's apparatus in the catalogue. I have found it expedient to obtain the catalogue beforehand and mark down those exhibits deserving of special attention. But surely a better arrangement could be found so that the catalogue could be used more in the nature of a guide?

Tuning Fork and Thermostat.

The successful transmission of wireless messages in facsimile has necessitated the development of a means of controlling with extreme accuracy the running of the transmitter and receiver. In the system which has been developed for use on the Marconi beam circuits, speed control is secured by supplying a synchronous motor with current from an electrically maintained tuning fork which is kept at constant temperature.



The tuning fork and thermostat synchronising control used by the Marconi Company in connection with facsimile transmission and beam wireless circuits.

The tuning fork and thermostat used for this purpose was shown at

(*Continued on page* 22.)

A Woman's View of Television

By BERTHA LUPTON

IT is about three years ago since I stood in the Science Museum at South Kensington, looking at the first transmitter designed and constructed by Mr. Baird for his experiments in television. I did not go specially to see this recent addition to the scientific wonders of the world; I simply *found* myself looking at it, and I wondered.

I would have you to know that I am no scientist. When looking at this first model in the South Kensington Museum of Science an old gentleman, who must have been very learned, explained to me that by means of this device one could see through space, and without wires, a person or movements of persons, or even scenes. This old gentleman was learned in the science of television. He could talk the language of the televisionist. He used mysterious terms such as *volts* and *amperes;* he referred to *photo-electric cells* and *selenium*, terms which can be understood only by those who are versed in the scientific language of the televisionist.

"Cause and Effect."

Every occurrence has a cause and effect. As I looked at that model in the Hall of Science I realised that the dummy's head, the large discs, and the peculiar little black boxes were but a means to an end, that they were the cause of an effect which is now accepted as television. I do know the meaning of the term *Television;* of the functions of the apparatus producing the effect I know nothing. I have forgotten what the old gentleman said to me; I have told you that I am no scientist. I came away from the Museum feeling that I had seen something mysterious; something of which I was more than half afraid. Yet, when I come to think about it, this is one's impression with every development in science, one wonders and is sceptical until the utility of an invention is apparent.

It was so at the commencement of the era of wireless telephony. When I twiddled the knob on the top of my little crystal set, and I heard the noises which I now know to be oscillations, I would snatch the earphones from my head. I was afraid; I did not know that the oscillation fiends were at work. Now, since I have discarded my crystal set for a one-valve international set, which, strangely enough, only gives me my local station, I accept all strange noises as a matter of course. The pleasure I get more than outweighs what, at one time, I thought was a nuisance.

Another scene from the play "Box and Cox," recently broadcast by television.

Reverting again to television, I would say that the impressions I gained in the Science Museum at South Kensington did not remain long in my memory; I have no mind for things scientific unless I am directly affected by them. I had, indeed, except for occasional references I saw in the press, forgotten all about it. Then came the advent of this journal, TELEVISION. I am giving away no secrets when I say that I have a brother who subscribes to it; often I take it to my bedroom, where I can be quiet, to try and see what it is all about.

"I am no Scientist."

But I am no televisionist; I do not understand the language of the science. I cannot tell you why the wire in the valve of my international set lights up, and I cannot tell you in amplification the meaning of the term *anode* or *milli-ampere.* I know nothing about *lenses* or *refraction;* the *spectrum* and *ultra-violet* rays do not convey any meaning to me. I am a woman. I am no scientist; yet I am sure that there is something in this new science of television which must be of interest to women such as myself.

I have found wireless to be useful; my little set has given me no end of pleasure. It is nice to listen to a song, an opera, a talk, or even a debate. But there is something lacking; something which causes an effort to be made on the part of the listener. It is not difficult to explain this. The effort to visualise what is occurring, an effort which must be made to complete an illusion, detracts, to a very great degree, the *possible* pleasure which *can* be obtained from broadcast reception.

Where the B.B.C. Fails.

The B.B.C. do their best to make things clear. At the commencement of a play or sketch they give an explanation of what one is about to hear. During transmission various scenes and actions of players are described. The object is to assist the listener to create the illusion upon which the success of a broadcast depends. How much better it would be if we could *see* exactly what is going on.

Let me give you a few examples of how we women would benefit by broadcast television. A few weeks ago a well-known society dressmaker was "explaining" how this and that was being worn; how they were trimmed, and a description of the fittings was also given. No matter how clever a person may be at explaining things, there is always something wanting.

The mere statement that "The material is gathered on the right side, a little above the hip; the appearance of the folds is enhanced by fitting a clasp of diamante immediately above them," is not sufficient detail for a woman who loves dress (and what woman doesn't?). A more comprehensive idea of what is meant is conveyed if the dress, folds, and trimming can be seen.

Again, consider those little home chats we had just before Christmas, when we were told over the wireless how to prepare this and that for the oven. Any woman knows that a little ocular demonstration is better than all the talking in the world. To prepare a turkey, for instance, telling you how to do it is not sufficient.

This is realised by nearly all the women's weekly papers. The editors of these journals are not content to tell you in bare print how to do it. Several photographs are taken at various stages of cleaning and trussing, at the most important stages of the operations. Even this is not sufficient. If a lecturer, as in cookery class, could be *seen* at work, I am sure that the lesson would be better learnt.

Just one more case—in the garden. How nice it would be if, during a lecture on, say, pruning, one could see the trees when following the reasoning of the lecturer. A lecturer with a rose tree and knife would proceed after this manner: "The branch must be held in the left hand *here*, just *this* distance away from the junction. It must be cut *here*, in *this* direction, not *that*." How helpful it would be. Although some of us may be experts on the subjects I have mentioned, there is not one of us but would like to know how the other woman does it.

Although I am no televisionist, but just one concerned with the effect and not the cause, I feel that I ought to encourage my brother in the development of television. I must make him enthusiastic enough to commence experimental work and join the Television Society. I must impress him of the importance to women of this new science. Then, who knows? I may desire to assist him; I may learn the language of the televisionist, in spite of the fact that I was afraid when I saw Mr. Baird's first model in that museum of science at South Kensington.

[Photo by courtesy of National Broadcasting Co., U.S.A.

WHAT A MODERN HIGH POWER BROADCASTING STATION LOOKS LIKE.

A portion of the equipment of WEAF, the National Broadcasting Company's 50 kw. station at Bellmore, Long Island, near New York. Left to right: Oscillator panel, tuning circuits, and high power radio frequency amplifier. The purposes of these pieces of apparatus are described in the series of articles entitled "Bridging Space."

Progress in Instrument Design.

(*Concluded from page* 20.)

South Kensington and is illustrated herewith.

The tuning fork is made of mild steel with low damping, and it is maintained in continuous vibration by reaction. The whole fork and mounting is placed in a heat-insulating box, and maintained at a set temperature (above that of the room in which the apparatus is used) by means of a toluol regulator. This closes a contact when the temperature reaches a certain predetermined value, and by means of a relay switches off the heater lamps which are on the right of the chamber. As soon as the temperature falls the contact opens and the lamps are switched on.

Two fans are placed at the top of the box maintaining the air in the chamber in constant circulation to avoid any temperature gradient, and by this means the temperature of the fork is maintained constant to within about 0·1° Fahrenheit.

The temperature can be observed by means of a thermometer, and if it is necessary to change it from the predetermined value to which the toluol regulator is set this can be done without opening the box. The heater relay with its controlling valve is contained outside the thermostat box. Valve control has been adopted for the sake of reliability, as the make and break of the mercury contact of the toluol regulator is sparkless under these conditions and no trouble is experienced from bad contacts.

The weak alternating current from the tuning fork circuit is amplified by a bank of valves, the anode current of which passes through the armature winding of the synchronous motor in the driving machine, thus maintaining it in synchronism with the frequency of the tuning fork or with that of some selected multiple. A similar device to that shown has a great field of application in maintaining a constant frequency of radiation in wireless transmitters of all types.

W. G. W. MITCHELL, B.Sc.

Television Society Special Notice.

In order to complete the printed list of members and also to close the annual balance sheet all members are requested to complete their payments, subscriptions, etc., within the present month.

Simple Two-Lens Optical Systems

Telescopes and Microscopes

Part VII

By Professor CHESHIRE, C.B.E., A.R.C.S., F.I.P.

IN our last article we gave (see page 42 of the January issue of TELEVISION) a graph (Fig. 5) for the power equation (5) of two thin separated lenses. We found it to be a simple straight line. Instead, however, of plotting the reciprocal of the focal length, $1/f$, as we did, we might have plotted the focal length directly from equation (3), on page 41. We will do this by taking the same pair of lenses as were considered for the curve on page 42. These lenses had powers of +5 and +4, diopters, respectively—that is focal lengths of 20 cm. and 25 cm.—so that from equation (3)—

$$f=\frac{20\times 25}{20+25-\Delta}$$

where Δ, as in Fig. 5, referred to, is the separation in *cms.* Thus when Δ increases from 0 to 50, f will have the corresponding values set out in the following table:—

Δ(*cm.*)	f (*cm.*)
0	11·1
5	12·5
10	14·3
15	16·7
20	20·0
25	25·0
30	33·3
35	50·0
40	100
45	∞
50	—100

Plotting these values we get the curve shown by Fig. 1, which will repay study. It tells us that when two thin lenses of focal lengths 20 and 25 cm. respectively (8 and 10 inches), are placed close together, they act as a single lens with a focal length of 11·1 cm., and, as they are separated, this focal length increases until, when the separation is 25 cm., the focal length also is 25 cm.

Beyond this the focal length increases rapidly until, with a separation of 45 cm., the equivalent focal length is theoretically infinitely great, the mathematician's way of saying that the combination of lenses then acts like a sheet of plane glass—parallel rays entering the combination leave it as parallel rays.

The student is recommended to plot these curves for values of Δ ranging from 45 cm. to 90 cm., for himself. He will get a curve similar to the one already plotted in Fig. 1, but which occurs in the bottom right-hand quadrant, defined by the horizontal scale line and the vertical dotted line passing through it at the point 45.

Optical Separation.

In our work so far, we have expressed the separation of two lenses directly as the distance between them. This simple method, however, can only be applied to thin lenses. When we have, as is usually the case, to consider thick lenses, and lens systems, such, for example, as microscope objectives and eye-pieces, photo lenses, etc., we are in a difficulty. There are no obvious points between which to measure. The positions of the equivalent refracting planes cannot be determined by simple observation, neither can they be found directly and simply by experiment. We can, however, determine the position of a focal point both accurately and easily, and so the distance between two such points. Such a distance between certain selected foci is known as the *optical separation.*

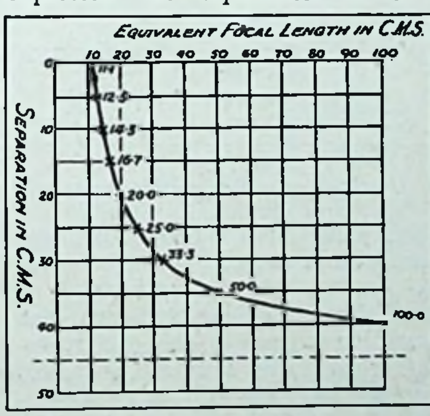


Fig. 1.
Graph (focal length) for two thin separated lenses of focal lengths 20 cm. and 25 cm.

In Fig. 2 three typical two-lens systems are shown diagrammatically. The first of these (*I*) we will adopt as our standard case.

A pair of separated convergent lenses are shown by it. Parallel rays from the right are brought to a focus by the lens B at the point F_1, and parallel rays from the left are brought to a focus by the lens A at the point F_2. The distance Δ between the two focal points thus got is defined as the optical separation. In *II* the lens B is a negative one, but the same procedure is adopted.

Parallel rays from the right and from the left are brought to foci F_1, and F_2, as before, and the distance between them is the optical separation. In *III* two negative lenses are dealt with similarly.

Taking the first or standard case (*I*) of Fig. 2 and tracing an incident ray through it to a final focus, in the way already described, we find that the focal length (f), of the equivalent lens is given by—

$$f=\frac{f_1\,f_2}{\Delta}\quad\ldots\ldots\ldots\ldots\ (1)$$

As an example of the use of this formula we will take the case of a compound high-power microscope, in which, knowing the focal lengths of the objective and ocular respectively, and their optical separation, or *optical tube-length* as it is called in this case, we can find the power of the microscope as a whole. Let the objective have a focal length f_1 of 2 mm., the ocular one of 15 mm., and an optical separation of 120 mm., then by equation (1)—

$$f=\frac{2\times 15}{120}=0\cdot25\text{ mm.}$$

The equivalent focal length of the microscope as a whole is a quarter of a millimetre, and, assuming that the least distance of distinct vision is 250 mm., the magnification of the image * seen is given by—

$$M=\frac{250}{0{\cdot}25}=1000 \text{ times.}$$

As a typical case of a low-power microscope combination let the focal length of the objective be 25 mm., that of the ocular 40 mm., and the optical tube-length 120 mm. as before. Then—

$$f=\frac{25\times40}{120}=8{\cdot}3 \text{ mm.}$$

and.

$$M=\frac{250}{8{\cdot}3}=30 \text{ times.}$$

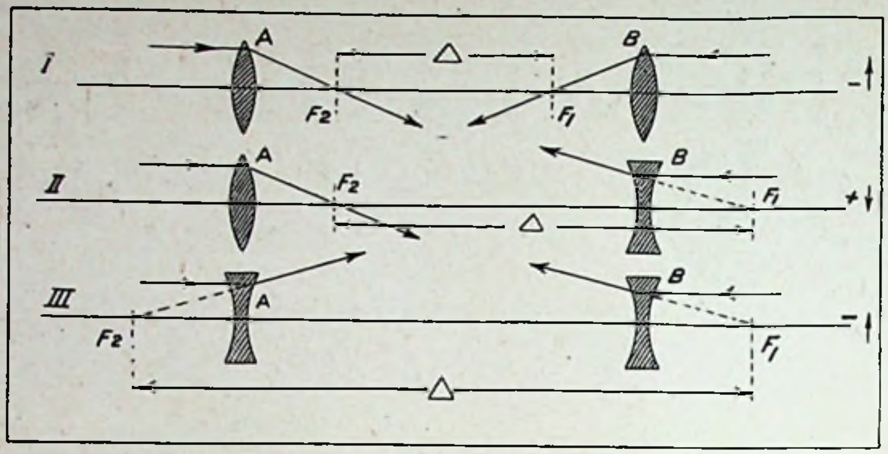


Fig. 2.
Typical illustrations of optical separation.

In the case of the astronomical telescope, adjusted for vision by a normal eye, the foci F_1 and F_2 coincide so that parallel incident rays emerge as parallel rays, and the focal power is zero, since Δ is now equal to *O*. A telescope in this condition is said to be in *normal adjustment.*

A Garden Telescope.

One of the most interesting and instructive optical instruments is what is sometimes called a garden telescope. This instrument consists essentially of an ordinary telescope in which the draw-tube, carrying the erecting ocular, is drawn out so far that objects only a foot or two away are seen magnified and in focus in the telescope.

The same result can be obtained even more perfectly by taking a pair of prismatic binoculars, focussed for distance, and sticking in front of each of the object glasses a spectacle lens of from 3 to 4 feet focal length. Each of these spectacle lenses should have the same focal length and should be adjusted laterally—the wax used for sticking the lenses will admit of this—until a single object is seen through the two oculars simultaneously. An object, such as a bee on a flower, is then seen magnified and in relief as in free vision. A flower bed affords an endless supply of beautiful and interesting objects for the garden telescope.

Fig. 4 shows diagrammatically the optical action of a garden telescope. *OG* is the object-glass; *EL* the erecting lens; and *Oc* the ocular.

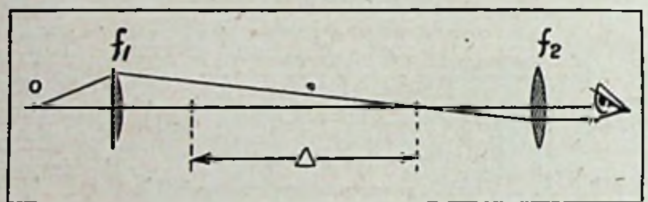


Fig. 3.
Diagram of optical system of compound microscope.

When in normal use and adjustment parallel rays entering the object-glass *OG* emerge and enter the eye as parallel rays. To adapt it for use as a garden telescope, the ocular, together with the lens *EL*, is racked out so as to produce an optical separation between the compound ocular (*Oc*+*EL*) and the object-glass (*OG*).

In this condition an object at a distance *D* (say) is seen in sharp focus and under magnification. An image i_1, of the object is projected by the *OG*, which is again projected by the lens *EL* into the image i_2, which is in the principal focal plane of the eye-lens *Oc*. The function of the lens *EL* is thus to erect without magnification the image at i_1, which is of course an inverted image of the object, which is thus seen erect in the telescope.

Equivalent Lens of Garden Telescope.

To find the position and focal length of a lens which would give the same magnification of the object as that given by the telescope, it is only necessary to draw a ray entering the eye parallel to the axis of the telescope backwards until it intersects the corresponding ray drawn from the object to the *OG*. Let this point be *E*, at a distance *f* from the object.

The complete telescope is, therefore, equivalent to a single lens placed at *E*, with a focal length *f*. An eye behind such a lens would see the object under the same magnification as an eye looking at the object through the telescope itself.

Put in another way, suppose that the object is first seen in free-vision at the distance *D* of the *OG* from the object, and then through the telescope. The linear size of the image in the last case, compared with that of the first, is in the ratio of *D* to *f*, so that if *D* be four feet, say, and *f* be six inches, the image seen through the telescope will be eight times larger in the second case than that seen in the first.

Galilean Telescope.

The arrangement of two lenses shown at *II*, Fig. 2, when the focal

(*Continued on page* 45.)

* The magnifying power of a single lens, such as a pocket magnifier, is conventionally obtained by dividing the least distance of distinct vision, assumed as 10 inches, by the focal length of the lens in inches. Thus a one-inch lens magnifies ten times, a half-inch focus lens twenty times, and so on.

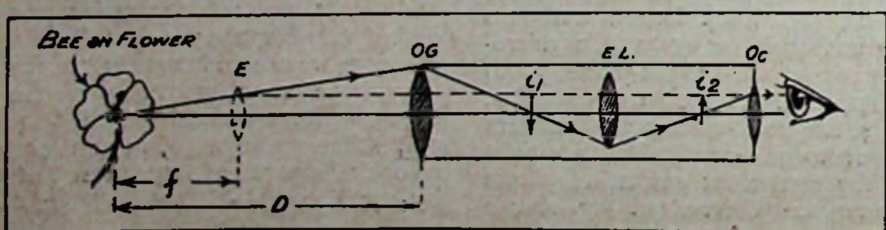


Fig. 4.
Diagram showing the optical action of a garden telescope.

HOW THE PUBLIC SAW THE SILENT NAVY

BY DEREK IRONSIDE

THE Executive Officer put his head authoritatively into the ward room, gripping the door to steady himself as the 40,000-ton battleship *Anglia* lifted to the Atlantic rollers.

"The Fleet's for battle practice at noon, Mr. Mountjoy. Admiralty instructs that the operations are to be televised."

Young Lieutenant Mountjoy, Official Televist to the Fleet, rose from his sprawling attitude and saluted the departing figure of the Executive Officer. His friend, Sub-Lieutenant "Nobby" Clarke, grinned at him, receiving in return a baleful glare.

"It's nothing to laugh at, Nobby," grumbled Mountjoy. "I'm fairly sick of these stunts. When the war broke out two years ago and I volunteered for television work, I really thought there'd be something worth televising. Instead of that, what do I have to send over to the long-suffering British public? Pictures of the *Anglia* taking in oil—a perfect study in slow motion—target shooting, close-ups of aircraft carriers, deck sports, and now battle practice! Why don't you fighting blokes get up a real scrap and give me something worth putting on the ether?"

"Steady on," growled Nobby. "Is it my fault? Anyway, don't you worry about it. When the fighting comes they'll batten you down safe and sound below—comparatively safe, that is, probably next to the main magazine. You won't get a chance of nipping into your little box on the foremast."

There was a rap on the door and Petty Officer Hoskins, Mountjoy's assistant, entered and saluted smartly.

"I understand you want me, sir. You'll find everything in order in the crow's nest. I overhauled the transmitter first thing this morning."

"Right you are, Hoskins. We'll get away up above at once. So long, Clarke."

And presently, whilst the huge battleships, battle cruisers, aircraft carriers, cruisers and destroyers manœuvred in sham conflict, Mountjoy's little aerial, slung between the control-top and the forward funnel of the *Anglia*, began to fling pictures across the Atlantic on to the screens of five hundred television halls in Great Britain.

* * *

The Prime Minister sat at his desk. He had flung his pen down and was gazing moodily at a pile of unattended correspondence. His face, lined by the anxieties and responsibilities of two years of war, looked weary and sad.

The door was flung open violently and three persons entered abruptly. The First Sea Lord literally breezed into the room, followed by a girl of twenty and a young naval officer.

"You do look down in the dumps, Sir Rupert," ejaculated the First Sea Lord. "Cheer up, sir. England's not done for yet."

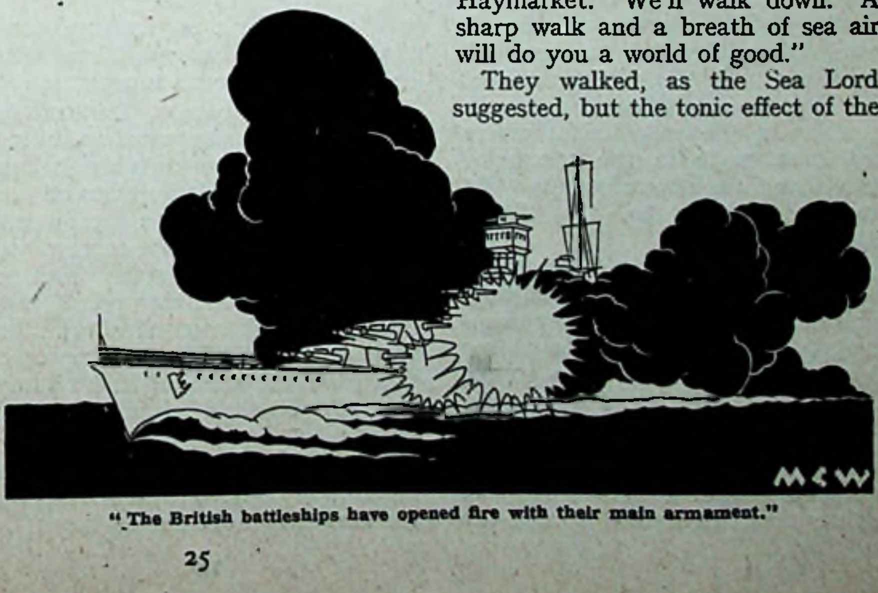
The Prime Minister looked up with a ghastly grin. "England perhaps not, but as regards myself I'm afraid I'm near breaking-point. This long war is getting on my nerves. The temper of the country is growing ugly. There's even talk of revolution Lord Bertram was saying . . ." He broke off suddenly as he realised that he and the Sea Lord were not alone.

"Your daughter literally dragged us over here, Sir Rupert," explained the Sea Lord, tactfully ignoring his chief's gloomy utterance. "You know my son, of course. We all think that a breath of sea air would do you a world of good."

"Sea air?" The Prime Minister looked faintly bewildered. "I can't possibly get away from here for days."

"My little joke, sir." The old sea dog's ruddy face broadened into a grin. "It's this fleet publicity television business, you know. Admiral Drake has radioed that the Fleet will televise its battle practice to-day, so of course all the television halls will be showing it. You'd better come along with us, sir. I've had a box reserved at the Piazza in the Haymarket. We'll walk down. A sharp walk and a breath of sea air will do you a world of good."

They walked, as the Sea Lord suggested, but the tonic effect of the



"The British battleships have opened fire with their main armament."

exercise was doubtful as far as the Prime Minister was concerned. As they crossed the square a newsbill flared at them with the words: "Sir Rupert Canning Must Go." Outside the Piazza Television Hall a huge poster announced in red letters on a white ground that television pictures of the Fleet's battle practice would be shown at 12 o'clock. A queue had already formed for the cheaper seats, and one or two people recognised the party. There were murmurs and some booing. The Sea Lord flushed a deeper red than usual as a Cockney youth enquired in a painfully audible voice "Why don't the Navy fight?"

They sat down in their box, the Prime Minister drawn and tense, the First Sea Lord bluff and jolly and Miss Canning and young Lieutenant Martin frankly proud and happy at being in each other's company.

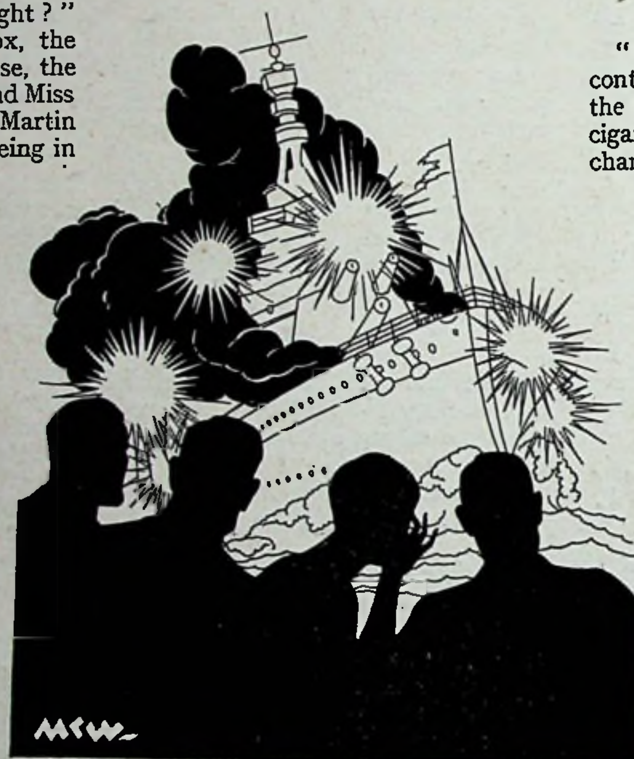
A title was flashed on the screen: "The Grand Fleet at Battle Practice." There was some cheering, then a voice called out "Why don't they fight?" followed by laughter and some disorder. The noise died suddenly away, however, as the screen flashed into life, and the huge audience found themselves gazing at the green rollers of the Atlantic through which the leviathans of Britain's naval might were forging at full speed. A party of men on leave from the *Nelson* gave a full-throated cheer as that imposing grey monster swept into and out of the picture. Watching that life-like representation of an event many hundreds of miles away, reproduced in natural colours and accompanied by the roar of the distant ocean, the First Sea Lord could not help thinking of the vast strides which had been made in the science of television since its early days. He turned jocularly to the Prime Minister.

"It's a pity they can't turn ozone on to us. It's the only thing wanting. Hurrah, there's the old *Rodney* foaming past. She was a wonder in her day, you know. And there go the destroyers. Devils for a fight when they get a chance."

* * *

Up in the little armoured nest, higher even than the control-top whence the Gunnery Officer would, in battle, direct the movements of the *Anglia's* guns, Mountjoy and his assistant felt peculiarly detached from the scene below. With almost mechanical precision Mountjoy appraised the constantly changing panorama and took his "shots" with a fine eye to pictorial possibilities. There was much to engage his attention. "Close-ups" of destroyers sweeping past succeeded telephoto "snaps" of distant battleships in line ahead formation.

He was engrossed in getting the right setting for a particular picture when Hoskins nudged him. He looked up with some annoyance.



"There was a sudden close-up of a battleship on fire from stem to stern."

"Something queer's happening, sir. This isn't the usual practice. We're all steaming together in line ahead with the destroyers out on the flank. Ten minutes ago the Second Battle Squadron was the enemy, but now we've joined forces. Half a moment, sir." Hoskins peered out through the observation slit in the armoured cage. "What's the game? Blessed if the Admiral hasn't hung out old Nelson's signal—*England expects*."

A sudden thrill ran swiftly through Mountjoy's body. He almost pushed Hoskins away from the sighting slit.

"There's smoke on the western horizon. By thunder, Hoskins, I'll bet that's old Vancotter come out at last. Every gun in the fleet is trained in that direction." He slapped Hoskins violently on the back. "It's Armageddon, Hoskins, and they've forgotten all about us. Here's the stage set for the most stupendous sea battle in history and we're perched here with definite orders to televise fleet operations. We'll give the old British public real value for its money this time. And just in case of accidents you might snip that telephone wire."

* * *

"It's wonderful how smartly they control these huge vessels," remarked the Prime Minister as he lit a second cigar. "The Fleet seems to have changed formation."

"Yes, they're in line ahead, sir. But what . . ." The Sea Lord's voice tailed off abruptly. "There's smoke on the horizon—trail after trail of it. None of our subsidiary squadrons are in that neighbourhood. Can it be . . . ? No, impossible! But yet . . . By Gad, sir, that smoke is Vancotter's fleet come out at last."

A loud speaker at the side of the screen suddenly gave tongue. "Whilst the Grand Fleet is at battle practice," the metallic voice rang out, "the enemy's fleet, commanded by High Admiral Vancotter, approaches. The Grand Fleet, commanded by Admiral Drake has assumed battle formation, and the two forces are now closing rapidly, their present approximate distance being thirty-five thousand yards."

The Prime Minister jumped to his feet. "We must have this stopped at once. This is unheard of—televising a battle." He tugged impotently at the Sea Lord's arm.

The Sea Lord grinned boyishly. "You can't stop it, sir. Let's see the fun through. We can always court-martial somebody for it afterwards. By Gad, old Drake's unleashed his airplane torpedo carriers."

The picture changed swiftly. In the foreground a line of lithe, low, evil-looking craft were now speeding rapidly, white bow waves curling along their slender sides. These were the enemy destroyers. Far behind them the tiny figures of the distant hostile battleships were silhouetted on the horizon. As the Sea Lord spoke, a wedge-shaped squadron of air torpedo carriers soared above the destroyers and receded swiftly into the distance.

Suddenly a tremendous crash of sound filled the hall and the picture on the screen heaved drunkenly. Women screamed and fainted. In the short silence which followed that ear-splitting detonation of the giant guns now giving tongue for the first time, the voice of the distant televist rang through the hall: " The British battleships have opened fire with their main armament of twenty-inch guns at a range of thirty thousand yards. The first salvo has fallen short."

Again the colossal roar of the guns filled the hall, drowning the voice of the speaker. But the rapidly changing pictures on the screen told their own terrible story.

The next scene was of the British battleships, curtained in billowing smoke, through which flame stabbed at regular intervals. The sea around the vessels was curiously disturbed, as the huge enemy shells fell about them and flung gigantic fountains of water into the air. Towards the leviathans were speeding the grim shapes of enemy destroyers, but these were quickly caught in a hurricane of shell-fire and one by one blew up, sank, or turned tail. And meanwhile, bursting shells winked and flashed around and upon the British battleships. The air was filled with the roar of guns, the terrifying hum of huge projectiles, and the ring of flying fragments of steel.

Excitement of Battle.

Miss Canning sat tensely in her seat, clutching at her father. The young lieutenant was following the battle, enraptured. Once his father heard him mutter " Just my luck to be out of this! There's my ship, the *Vesuvius*, going past. Great Scott, my own barbette is out of action, clean hit by a shell! I wonder if any of the boys are left."

Now above the crash of gunfire rose a deeper roar. There was a sudden close-up of a battleship on fire from stem to stern. As the watchers gazed, her decks opened and a vast pillar of steam and flame leapt heavenwards. The distorted, red-hot hull slipped sizzling beneath the waves.

" That was the British battleship, *Britannia*," came the voice of the televist. " Her boilers and magazines exploded. The cruiser *Doric* is racing to rescue the few survivors. The *Vesuvius* is also out of action with damaged steering gear. So far the enemy have been badly raked, but we have scored no vital hits."

" This is Jutland over again," moaned the Prime Minister through clenched teeth.

" Don't you believe it, sir. Our gunnery's a hundred per cent better than it was in 1916. I trained these gunnery officers myself when I was head of the Gunnery Branch. We're losing ships now but can't you see the position for which old Drake is so adroitly manœuvring. He is going to perform the trick of 'crossing the T.' In a minute every big British gun will be raining fire upon the leading enemy ships. See that sudden turning movement! By Gad, sir, he's got them."

The loud speaker roared out. " The British Fleet, by superior seamanship, has secured the tactical advantage. You will see the effect of our gunnery in a few moments. Thanks to the exertions of the present First Sea Lord, whom we know in the Service by the affectionate title of 'Walrus,' British gunnery is second to none in the world."

Again the picture changed and now the audience were looking at the enemy squadrons advancing in line ahead. Even as they gazed, the leading monsters reeled as though punched by huge invisible fists. Funnels, fighting tops and gun-turrets were literally swept overboard and swift explosions which ripped out decks and sides with amazing suddenness completed the destruction. Within a minute five huge battleships had plunged below the surface. Then once more the British guns roared out and fresh explosions further down the enemy column testified that other vessels had also met their doom.

" My God! " exclaimed the Prime Minister. " This is annihilation."

" It's the Nelson touch," ejaculated the First Sea Lord. " The enemy's turning tail. There go our destroyers after him. Confound the smoke! Half of his vessels that are left will never reach port. Just look at that big battle cruiser burning."

As the smoke cleared away, there was a sudden lull in the gunfire. The old First Sea Lord leapt to his feet and his voice echoed commandingly through the hall.

Victory.

" Three cheers for Admiral Drake. Vancotter's hauling down his flag."

Pandemonium broke out in the huge auditorium. Wave after wave of cheering rang through the building. Then a voice called out " We want Sir Rupert Canning and the Sea Lord. Speech! Speech! "

The Prime Minister went to the edge of the box and leaned forward. He chose his words carefully, obviously under the stress of deep emotion.

" We have been privileged to-day to see one of the decisive battles of the world. I am still too greatly affected by the spectacle of this stupendous conflict in which the sons of Britain have so worthily carried on the traditions of our Island Empire to say much to you, but I feel convinced that within a week we shall have the peace for which we all yearn and that the shadow of the past two years is at last about to be lifted." He sat down abruptly amidst a storm of cheering.

* * *

" And what about that court-martial! " enquired the First Sea Lord, as they walked back to Downing Street. " Did you hear what that Fleet Televist said about me? "

" There's going to be no court-martial," said the Prime Minister decisively. " I've earmarked that young devil for a decoration."

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The Television Society

Report of January Meeting

Mr. J. DENTON ON TELEVISION RESEARCH

THE January meeting of the Television Society, held at the Engineers' Club, Coventry Street, London, on January 1st, was to have been addressed by Mr. J. Cameron Rennie on "Exploring Devices." Owing to indisposition he was unable to do so and his place was taken by Mr. J. Denton, one of the hon. secretaries of the Society, who spoke on "Research and Television."

DR. CLARENCE TIERNEY, the Chairman, calling on Mr. Denton to give his lecture, said he felt they would all appreciate that television was one of those delightful sciences for which this country could take credit. It was due entirely to the persistent and dogged determination of the amateur not to be put off by disappointment.

We were all more indebted to the independent worker for the advances and facilities of modern life which we enjoyed than our authorities were inclined to recognise. The independent worker went quietly ahead in his own laboratory until he reached the goal he had in view. Such was the position of television, and they could depend upon it that had its development depended on officialdom there would have been no television. The difficulty was to get it recognised now that it had been accomplished.

It gave him great pleasure to call on Mr. Denton to give his lecture.

MR. DENTON said it was without any hesitation that he chose the subject of "Research and Television" as a suitable one to interest them in the enforced absence of their lecturer.

The subject of scanning or exploring the object to be televised was originally announced for the lecture, and was a branch of research that had a special interest for the experimentalist in the science of television, but he proposed to deal more generally with the subject and trace the development of the particular frame of mind which was necessary for scientific research, and to suggest practical work by which the amateur could advance television.

Studies of the Ancients.

Examples from the past were helpful. The Ancients, like ourselves, realised the problems around them, but brought to their work the usual prejudices of the undisciplined mind.

They were attracted by the study of astronomy and thought that the heavenly bodies must be perfect, and therefore, from this, that their orbits must be circles (a perfect form), and even supposed that spirits carried them around the sun.

Mathematics appeared early in history, but the early workers were more concerned with superstition than with science. Mathematics was studied for astronomy, and astronomy for astrology. Throughout the history of geometry the Euclidian axioms were long considered to be unescapable truths.

In the Ptolemaic system the earth was the central figure, fixed and motionless, with the moon and planets moving around it. It became eventually an extremely complicated system, due to added observations of later generations, which had to fit in with the preconceived ideas based on the "incorruptibility of the heavens," by which Aristotle had influenced Ptolemy.

This error retarded the discoveries of science for hundreds of years, and it was not until the sixteenth century that any serious advance was made.

It was in this century that Copernicus laid the foundation of modern science by using mathematics as the basis of his astronomical system. Here the sun was made the centre with the earth moving in a circle.

His ideas were so revolutionary that he studied them, not only by meditation but by observation, for twenty-six years before he published them in the year 1543.

The sixteenth century was rich for us, in that it brought the beginnings of science as usually taught to-day.

We had Kepler, who harmonised and simplified the mathematics of the Copernican system, but he, too, believed in charms and amulets.

But it was needless to follow that history, except to mention Descartes, who was so satisfied with science that he said: "Give me matter and motion and I will construct the universe." He considered all ideas had been closed and that science was complete.

Work of Galileo.

Galileo followed, and sought for other than geometrical qualities of matter. He considered mass a necessary conception. It was thus that matter became materialised and that time and force were necessary for a physical concept. It was he who introduced the idea of forces being primary causes.

It was at the time of Newton that our interest began, and it might interest them, sitting there, that Newton lived close by; in fact, at a house at the corner of Orange Street and St. Martin's Street, W.C.2.

He endeavoured to replace the "occult" by the "familiar," and chose as fundamental entities absolute space, absolute time, and the absolute property of matter, "inertial mass," and for convenience, the concept of force.

To him the axioms of Euclid were rigid and true and, in fact, unescapable, and many to-day considered that the axioms of Euclid still held, if they were not influenced by modern work. To him Euclidean geometry was the only conceivable geometry, and being born in the year of Galileo's death, he was influenced probably by Galileo's ideas of mass and force. This contributed to the deliberate adoption of guiding principles and concepts which culminated in Newton's laws of gravitation, as expressed in terms of force, mass and acceleration, and his explanations in terms of the familiar, the value of which is confirmed to-day by the statement that Force equals the product of Mass and Acceleration.

The lecturer here suggested experiments based on Newtonian laws, and closed the review of this period.

A New Era.

Bernard Riemann, the German geometer, started a new era for the research worker, by introducing a more physically descriptive geometry than Euclid. And Gauss, who was so well known due to his work on magnetism, constructed a perfectly consistent geometry which denied the parallel axiom, but when he realised that it would be regarded as "shocking," he was afraid to publish his researches. So it was left to Einstein to revolutionise physical science by the introduction of new concepts and principles, influenced probably by the earlier workers, Riemann and Gauss. Yet Einstein stood out as an original thinker in his field of research.

In the lecture given recently by Major Church, attention was focused on the research work of Michael Faraday. And here they must specially consider the markedly original work of Clerk-Maxwell. It stood out as remarkable that another research worker, Lord Kelvin, would not believe in the possible results of Maxwell's theories, yet Maxwell had based his mathematics on the experimental work of Faraday and had brought his original mind to foresee the consequences of Faraday's results.

Kelvin was engrossed in his measurements and the wonderful instruments he constructed, and is credited with saying he would not believe anything of science of which he could not make a model. To-day it was Eddington who so clearly gave us a new sense of possibilities, and by the aid of Einstein's influence showed us that science was not merely a collection of recipes for making instruments and continuing processes.

So, in exact research work to-day, we found that for modern physics a new way of thinking was necessary. And to-day the student was no longer unduly influenced by the materialistic age, with atoms like marbles, and ancient ideas with which to construct the universe; all this was a matter of history. The electron, experimentally discovered in 1897, modified the atomic theory, for its mass was found to be 1/1800 the mass of the hydrogen atom.

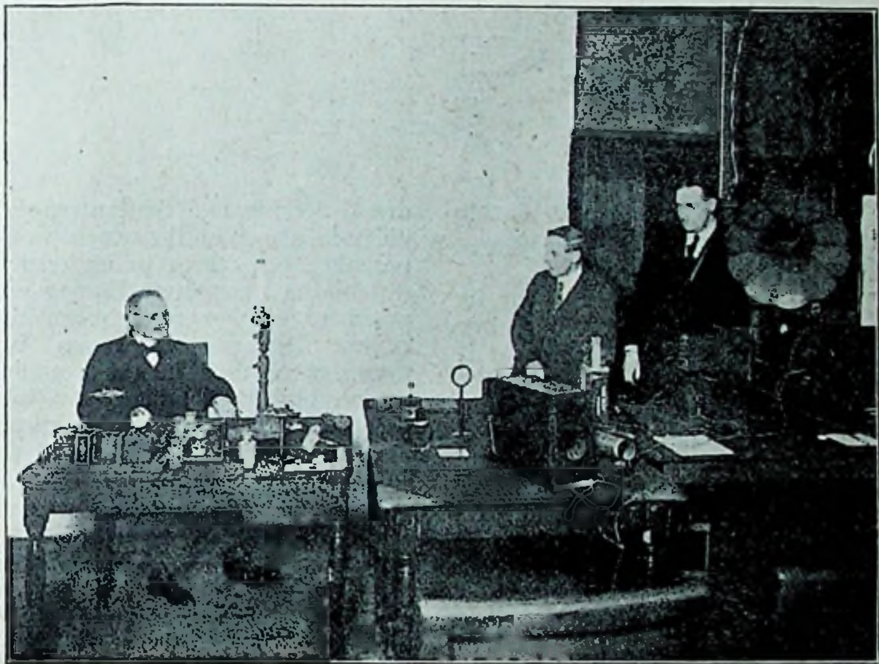
Plank and Bohr by their researches induced us to consider energy as atomic, and to make the terms matter and energy interchangeable, and thanks to Prout, Bequerel and Rutherford, we had some understanding of the building up and the breakdown of the heavier atoms, as well as a picture of the structure of the simpler atoms.

Röntgen's discovery of the X-rays created a new tool which in the hands of Mosely provided for the laboratory worker and the mathematician the means of exploring the structure of crystals, and strengthened information regarding the finer particles of matter.

Ionisation Demonstrated.

Here the lecturer referred to ionisation by X-rays, and demonstrated the action of radium in discharging a charged electroscope, by the aid of the ionised track between the electroscope and the distant radium capsule, so that the shadowed gold leaves on the screen were seen to collapse as the disintegrated particles and rays from the radium affected the charge.

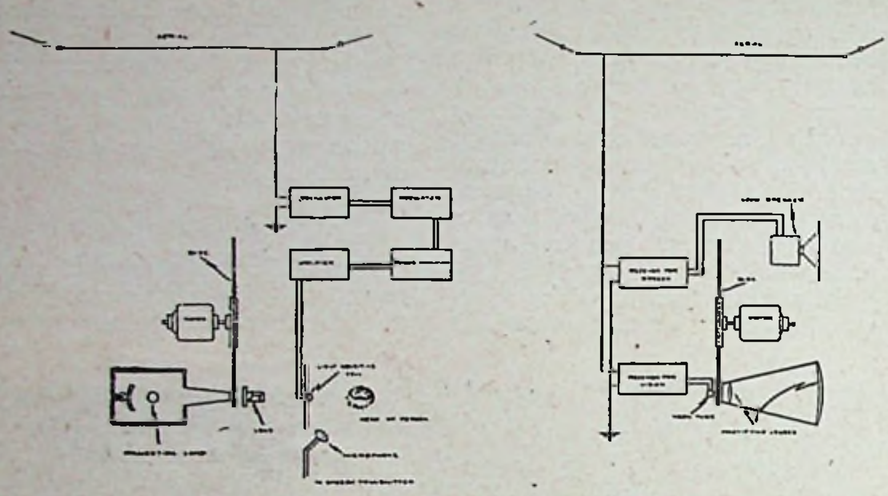
In a similar way metals with a polished surface could be fitted to the electroscope, and the metals, under the influence of light rays, would leak the charge. The rate of this leak of charge afforded us not only further knowledge of the elements, but helped us to design photo-electric cells, suitable for the energies of light reflected from the subject



Dr. Tierney (Chairman), Mr. J. Denton and Mr. W. G. W. Mitchell, Joint Hon. Secretaries of the Television Society, photographed with some of the experimental equipment which Mr. Denton used in the course of his lecture on January 1st.

or scene to actuate the transmitting televisor.

Having brought his review of scientific development up to date, Mr.



BAIRD'S SPOTLIGHT SYSTEM

Denton said he proposed to devote the remainder of the time to diagrams and experiments.

As a scientific society, with its groups throughout the country, they must not overlook the fact that it could be of considerable use to the individual experimenter. In circumstances where one could not buy a costly piece of apparatus, the group could purchase, and working together they would be able to follow up experimental work or carry out new work for themselves.

Research for Members.

In television work they had at one end a light-sensitive device, and at the other a sensitive light, which would, by the aid of the electric discharge, give sufficient illumination to enable them to build up the image of the receiver.

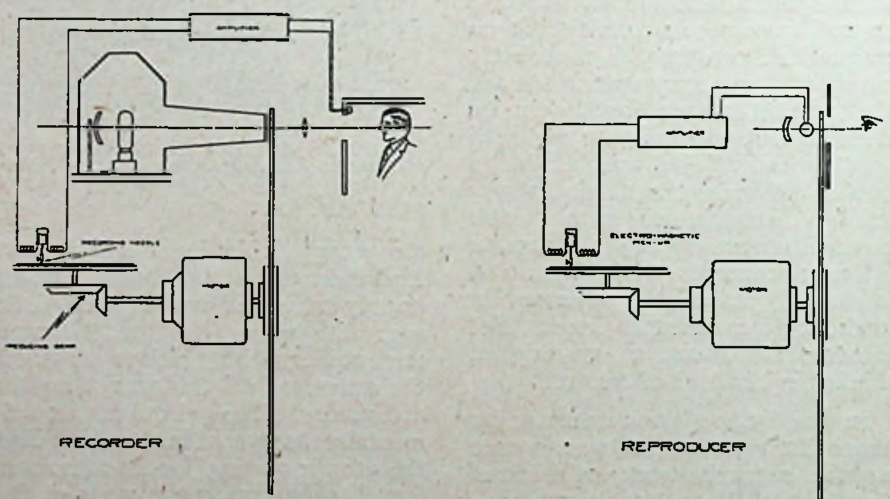
The design and the investigation of the characteristics of such tubes and further discoveries which would lead to the making of better types of tubes, was a class of work which was suitable for the amateur and might very well be taken up by the various group centres of the Society which were being formed all over the country.

In dealing with the light-sensitive devices, first it was necessary they should understand something of the photo-electric effect.

From a television point of view this formed a good starting-point.

It would also be of help if they studied suggestions and attempts that had been made to achieve television. The first of these was due to Rosing, and the lantern-slide diagram, shown on the screen, would probably help them to understand it. In the transmitter Rosing proposed to employ a light-sensitive device. Mirrors rotated on two drums were used in the scanning device, and the cathode ray tube was suggested as a suitable means of reconstructing the picture at the receiver.

Here Mr. Denton demonstrated



Diagrammatic view of the apparatus used for recording and reproducing phonovision.

the movement of the cathode ray by the aid of a magnet.

So one of the earliest methods suggested for television was to use a photo-electric cell and the cathode ray. But although a great deal of work had been done to try and develop the cathode ray, it had not yet resulted in making possible a satisfactory demonstration of television, although it would seem that, not having weight, it should be a very suitable thing to use.

A considerable amount of research work was done by Korn, on the application of the photo-electric effect, but he did not turn his attention to television successfully.

They all knew the history and the light-sensitive properties of selenium.

Selenium was quite easily formed into a cell. The two most generally used types were the wire-wound and graphite type, and the condenser type.

Selenium Cells.

In the former a suitable resistance wire was wound or a graphite conductor marked out, around a non-conducting material, such as a strip of slate or unglazed porcelain, and a very thin coating of selenium rubbed over the spaces between the conducting layers.

To make a condenser type, one built up a mica and copper-foil condenser, carefully smoothed off the edges of the mica and copper on one side to give a perfectly even surface, and then covered that surface with a very thin coat of selenium.

To put the selenium coat on, one had to heat the metal until it was just workable and no more. This could best be done on the face of an electric iron, and a resistance in the iron circuit gave one a very fine control of the temperature and made the making of cells a very simple and easy process. Hooding the electric flat-iron made a simple oven for this purpose.

Having coated the cells, they should be tested for freedom from parasitic noises and response to light. This was easily done by a simple light chopper, such as was described in an early number of TELEVISION, consisting of a disc with a number of holes within its edge, rotated by a motor.

A beam of light interrupted by this disc, when allowed to fall on a cell, would set up in the electric circuit of which it formed a part, current impulses which in a pair of phones or loud-speaker would give rise to a musical note.

Selenium Cells Demonstrated.

This the lecturer demonstrated with the actual apparatus set up on the table. He also showed the effect of passing the hand with fingers outspread through the beam, and allowed the audience to hear the parasitic noises to which all selenium cells are prone.

He mentioned that he had brought a number of different types of cell for them to inspect at the close of the lecture.

For many years after the discovery of selenium it was hoped and believed that it provided the solution to the problem of television. Even as early as 1883 an article appeared in the *Journal of the Telegraphic Engineers*, discussing the properties of selenium and saying that it had made possible seeing by electricity. The editor even stated that a box, which contained an apparatus for seeing by electricity, had been left with him by the inventor of the telephone.

Jenkins in America was a persistent worker and had developed the shadowgraph method of transmission, but he had not yet shown real television comparable with what they had seen at a previous meeting.

Belin, another worker, having outlined a television scheme, had admittedly devoted himself to photo-telegraphy and had got off the track of research in true television.

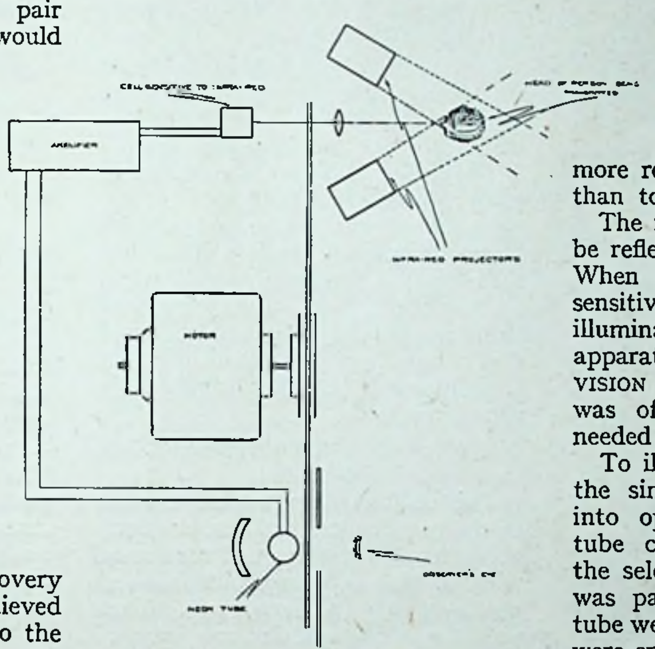
Mihaly was another worker in the field of whom they had heard much, but he, too, had done more with photo-telegraphy and shadowgraphs.

His (Baird's) system was quite well known, but a diagram of it might help them to recall it to their minds.

Mr. Denton than showed a lantern-slide diagram of the spot-light method used by Baird (Fig. 1).

When considering what was available for television research, they had to consider the light which would be used to actuate their light-sensitive device.

They could use ordinary white light or they could employ the ultra-violet rays or the infra-red rays, both of which were invisible.



NOCTOVISION

The arrangement used for noctovision purposes. The person to be transmitted sits under infra-red ray projectors. These rays are invisible, so that the person being transmitted sits in total darkness. In the above diagram both transmitter and receiver are shown for the sake of clarity, operating on the same disc.

Uses of Infra-red Rays.

In the early days of his work Mr. Baird was faced with the problem of lighting his subject; and, as he found the light required was so intense that nobody could stand it for any length of time, it led to him experimenting with the invisible rays. As they were aware, that had resulted in the development of noctovision, by the use of infra-red rays (Fig. 2).

At his lectures in Glasgow, Dublin and Newcastle last year he demonstrated the use of infra-red rays by ringing bells and exploding bombs.

A slide of the solar spectrum was shown and the ultra-violet rays, which occur beyond the blue end of the spectrum, were demonstrated by the aid of the lantern and suitable light filters, and a screen which fluoresced.

An Interesting Series of Slides.

In this connection, too, a number of slides of different subjects photographed in ultra-violet and infra-red rays were shown. They indicated that different materials had different reflecting powers, a piece of information which was of use when considering the lighting of the subject to be televised. All light-sensitive devices were not useful for television purposes either, because some of them responded more readily to one group of rays than to another.

The infra-red group of rays could be reflected, refracted and focussed. When carrying out tests of light-sensitive devices and methods of illumination, the simple shadowgraph apparatus described in the TELEVISION magazine some months ago was of considerable value, for it needed no synchronising.

To illustrate what could be done, the simple light chopper was put into operation again and a neon tube connected to the output of the selenium cell. When the hand was passed through the beam the tube went out, while when the fingers were spread out and passed through the light beam the neon flickered.

An Amusing Experiment.

Conversely, the loud-speaker used as a telephone could be made to cause the neon to flicker, and, much to the amusement of everyone, Mr. Denton sang and spoke into the loud-speaker horn and the neon tube flickered and glowed in response, then switching over the loud-speaker to the output of the amplifier he imitated the image sound. This led naturally to the question of phonovision, wherein an image is stored in a gramophone record as sound. With a gramophone pick-up and a televisor this image could be reproduced at any time (Fig. 3).

Such a record was played on a small portable gramophone, Mr. Denton explaining that it was his face which was producing the monotonous sound they heard.

Another record, of his hands, he illustrated by holding his hands in the relative positions they occupied when televised, and turning them in time with the changing sound from the record, thus showing how every variation in a scene being televised created a different electric impulse and, in the case of the record, a different sound.

Following this, several types of neon tubes and photo-electric cells were shown or illustrated, and Mr. Denton referred to colour and stereoscopic television, both of which had only been achieved in England, and that by Baird.

Briefly describing the system of colour television, he mentioned that it provided a very fascinating branch of research. So far only simple scenes had been transmitted, such as flowers and a basket of strawberries, etc. But enough had been done to prove the practicability of colour television. Here Fig. 4 was described, with Fig 5, showing the multiple reflecting device adopted by Mr. Baird to increase the light required to affect the cell

"I am afraid," said Mr. Denton, concluding his lecture, "that I have taken up your time by doing little more than suggesting headings under which research might be carried on, or subjects which we might pleasantly discuss."

Those who were anxious to do research work in television could not do better than get into touch with the secretaries of the Society.

They were trying to get together an index of the literature available, and he hoped that before long they might get the books. These might be followed by apparatus, but it all depended on themselves and the way the Society developed.

DR. TIERNEY, thanking the lecturer, said he was sure they had all listened to a very fascinating and stimulating lecture. If anyone was competent to deal with the subject of research, the lecturer was, for he had spent a lifetime at it, and had the habit of probing a subject as far as it was possible to go. When one spent most of one's life at that sort of thing one realised there was very much more to learn than one already knew. That, after all, was the stimulus and spirit of research. The man who sat down, satisfied with what he knew, was a fool and need not be reckoned with. Unfortunately very often in scientific work such self-satisfied people were in a position to hamper it, or its application for the public good.

The principal aim of almost everyone in this world was that of getting one's living, and when a man like Baird or Jenkins made a discovery that had a practical application, all their other research work had to be neglected while they perfected every detail of the application of their discovery so that it might be commercialised.

Value of the Independent Worker.

This only went to prove the value of the independent worker, or group of workers, who were not concerned with making a living, but followed the work for the love of it. That was the most satisfactory way of solving the abstract problems of science.

At a future meeting of the Society, probably in March, it was proposed to have a display of members' work and an informal discussion of any points that interested them.

He hoped that those who conducted experiments and intended to show apparatus would give the secretaries due notice of the amount of table space required, so that the meeting might be well organised.

On the suggestion of the Chairman a very hearty vote of thanks was passed to Mr. Denton.

DR. TIERNEY then announced that anyone who wished to visit the annual exhibition of the Physical and Optical Society, held at South Kensington on January 8th, 9th and 10th, could secure free admission tickets on application to either of the joint-secretaries of the Television Society.

The exhibition afforded a good opportunity of getting into touch with the people who made and used the class of instruments in which they were interested.

An alteration had to be made in the lecture arranged for January 1st. Owing to indisposition Mr. Cameron Rennie was unable to appear personally to give his paper on "Exploring Discs" as announced in the magazine and circularised to members, and time was too short to give notice of the change through the post. We are, however, glad to say that Mr. Rennie's paper is merely postponed and will be given at a later meeting of the Society, probably in May.

Mr. J. J. Denton, A.M.I.E.E., one of our energetic secretaries, kindly stepped into the breach at very short notice and gave our members a thoughtful and inspiring address (reported above) on the scientific

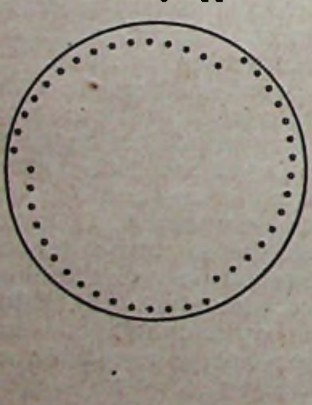


FIG 1

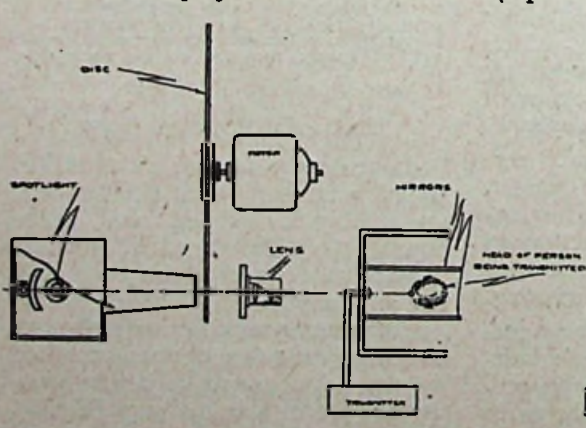


FIG 2

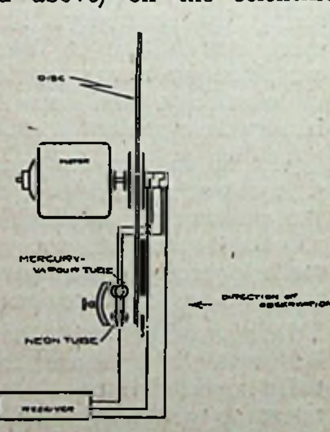


FIG 3

Colour Television layout. Fig. 1 shows the form of disc employed. Three spirals of holes are covered with red, blue and green filters. Fig. 2 shows the arrangement of the transmitter, and Fig. 3 the receiver. The neon tube provides red light, while blue and green are produced by a specially designed helium and mercury vapour tube. A commutator on the disc motor switches the incoming television impulses on to the appropriate tube so that the correct colour is reproduced.

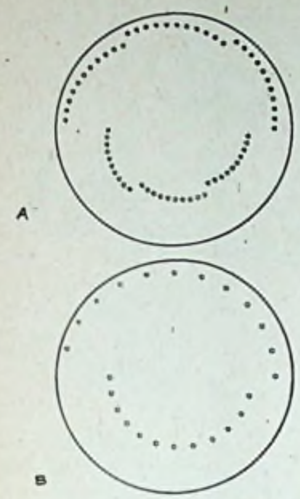


FIG 1

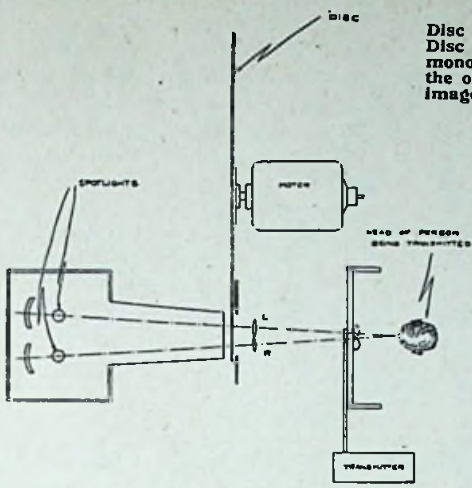


FIG 2

Disc A is used for stereoscopic television in colours. Disc B is used for stereoscopic television in ordinary monochrome. One spiral gives a right-eye view while the other gives a left-eye view. At the receiver the two images are merged into one by means of a stereoscopic viewer.

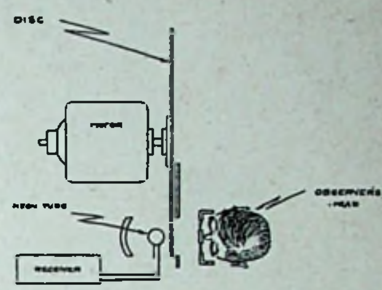


FIG 3

STEREOSCOPIC LAYOUT

attitude of mind necessary for the research worker. The writer of these notes can testify to the feverish activity which prevailed at the Engineers' Club meeting room when he called there on the afternoon previous to the meeting. Mr. Denton was directing operations, and several willing assistants were busy setting up the experiments which he afterwards used to illustrate points in his address.

Altogether, members were unanimous in voting this an enjoyable and stimulating evening's programme, and we hear that the secretaries are busy considering plans for future occasions where simple experiments can be used to such good purpose.

A Change of Plans.

This alteration has, however, necessitated a further change in plans for the next meeting on February 5th. The Council feel that the occasion of the annual general meeting to be held on the first Tuesday in March would be more acceptable to members for exhibits of apparatus than the February meeting as announced last month. Accordingly a lecture has been arranged for Tuesday, February 5th, at 8 p.m., at the Engineers' Club. The lecturer will be Mr. R. R. Poole, B.Sc. (of University College, London), and his subject will be "Methods of Light Modulation in Receivers."

By postponing the informal evening for one month the secretaries hope to be able to gather together apparatus truly representative of the activities of members of the Society. The response to an appeal for members to offer to show any experiments or apparatus they had made revealed the fact that, in spite of the meagre facilities for picking up transmissions at the present time, and in the absence, too, of lack of definite experimental details of transmitting plant, efforts were being made to re-create the vision signals sent out in this country and from America. These efforts were meeting with a certain measure of success. Other members we know are carrying out investigations into the fundamental problems involved in television.

When we recall the part played by the amateur in the progress of "wireless," we cannot but hope that those of our members who are actively engaged in their various researches will, some of them at least, ultimately contribute to the progress of television. To further assist the officers of the Society in their work of co-ordinating individual effort and avoiding "overlap" of experimental investigations, a "questionnaire" is being circulated which it is hoped members will fill in and return at the earliest moment.

Importance of Team Work.

Last month we referred to the importance of "team work" at the present juncture if the Society was to succeed as a live organisation. Well, send in your replies to the "questionnaire" in the spirit of co-operation.

We are glad to note that some thirty members of the Society availed themselves of the opportunity of attending the exhibition of instruments arranged by the physical and optical societies at South Kensington early in January. The officers of the Television Society wish to thank these societies for kindly sending invitations to our members.

Our daily postbag at headquarters seems to be getting heavier every day, and members are asked to be indulgent if replies to their letters are not received immediately. Every effort is made to attend to correspondence promptly, but as both of our hon. secretaries have a number of lecture engagements in different parts of the country, delays sometimes occur which are almost unavoidable.

Interest from Abroad.

A feature of the past month's correspondence has been the number of applications received from abroad for membership of the Society, which shows that other countries are not inactive in their interest in our common problems of re-creating vision sent from a distance. There has been a steady growth in our roll of membership, and we anticipate several important groups being formed in the near future.

Kindly note next meeting, Tuesday, February 5th, at 8 p.m., at the Engineers' Club.

J. DENTON,
W. G. W. MITCHELL,
Joint Hon. Secretaries

The Story of Electrical Communications

by

Lt. Col. CHETWODE CRAWLEY, M.I.E.E.
(Deputy Inspector of Wireless Telegraphy, G.P.O.)

Part II.—RECORDING INSTRUMENTS

John's Printer.

THE first recording instrument was made on the lines of the sounder, a steel style being brought into contact with a paper tape drawn along by clockwork, but this was soon supplanted by an ink writer which was invented as long ago as 1854 by John, an Austrian engineer. John used the same principle, but substituted a wheel for the style. The wheel was revolved by clockwork, which also propelled the tape, and its lower half dipped into an ink reservoir. As the armature was attracted the wheel pressed against the tape and made a mark, a long one for a dash and a short one for a dot. All the morse printers which have since been developed are mechanical improvements of John's instrument.

Many excellent recorders were designed and tried in those early days, but practice lagged behind invention, primarily because the volume of traffic did not justify their development for commercial service. However, in due course, telegraphic business began to increase so rapidly that it became essential to increase the traffic capacity of lines on the more important routes, and serious attention was turned to automatic working.

Wheatstone's Automatic Apparatus.

The first automatic apparatus to be used extensively in this country was Wheatstone's equipment, and in its later form it is still used on many circuits. The apparatus consists of a perforator for punching holes in a paper tape which is then fed into the sender, and at the receiving end a printer, on the general lines of John's instrument, which prints the morse code signals on a paper tape. The message is first punched up on the tape in the morse code, three punched holes in one vertical line corresponding to a dot, one hole in the middle corresponds to a space, and four holes (one above, two in the middle, and one below) corresponds to a dash. The holes in the centre are smaller than the others, and are only for use in connexion with the mechanism for moving on the tape. When the punched tape is passed through the transmitter by clockwork two vertical rods press against it, and every time the holes come along, the rods pass through and make electrical contacts, by which means the message is transmitted along the line in the morse code. The message is received in the form of dots and dashes on the tape of the printer, and is written up by hand or typed on the telegraph forms.

TELEVISION is the latest and fastest means of communication known to man. It is also a form of *electrical* communication. It will be interesting at this stage, therefore, to consider the history of the development of electrical communications generally —an enthralling subject which makes extremely fascinating reading. In the following article, the second of the series, our contributor deals with the invention and development of recording devices for line telegraph work.

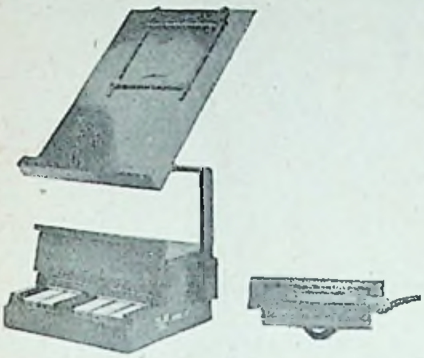
In the later forms the punching of the tape at the transmitting end is done by an operator on a typewriting keyboard. That is to say, a sending operator transmits by working an ordinary typewriting keyboard, and a receiving operator types up the message, which comes to him n a paper tape in the dots and dashes of the morse code. This apparatus has been vastly improved in detail by the engineers of the Post Office, and it is still one of the finest equipments available for the rapid disposal of traffic, at speeds up to 400 words a minute.

Creed's Receiver.

Much time is, of course, occupied in typing up, or writing out, the message from the tape, and to obviate this a most ingenious receiver, invented by Mr. Creed, of England, is now extensively used. With this apparatus messages can be received up to a speed of 125 words a minute in printed characters on a gummed tape, which is stuck straight on to the telegraph form.

The Baudot.

So far we have been considering what is called simplex working, that is the transmission of only one message at a time over the circuit, but the traffic over one line is often so heavy that some form of multiplex working is required. In this country the standard practice for the most heavily loaded circuits is, now, to send four messages and receive four messages simultaneously over the same line on what is called the Baudot system.



THE BAUDOT.

The total number of words a minute that can be dealt with by this arrangement is 240 by manual, or 400 by automatic transmission. The original apparatus was invented as long ago as 1874 by Baudot, a Frenchman. His apparatus was not welcomed at first even in his own country, and was not introduced over here until 1897. Indeed, the whole story is one long tale of tragedy, and Baudot himself, one of the greatest inventors in the annals of modern telegraphy, worn out by worry and disappointment, died in a lunatic asylum.

The Baudot is a five-unit system, the messages being sent, not in the morse code, but by a combination of five positive or negative impulses. Hand transmission gives a speed of 30 words a minute, and up to 50 words a minute can be obtained by automatic transmission. In the latter case typewriter keyboards are used for the perforation of tape, which is automatically fed into the machine transmitter. At the receiving end, in both cases, the messages come out as printed letters on the paper tape.

The Hughes.

Another important machine system, which is still used on many continental circuits, was invented in 1854 by Hughes, of England, so famous as a pioneer in wireless and as the inventor of the microphone. The Hughes system is not now used in this country except on some cross-channel circuits. The transmitting keyboard is like that of a piano with 28 black and white keys, and the letters are produced by single signalling impulses separated by a variable number of units of time. It can work up to 50 words a minute simplex, or 100 duplex, but is not adaptable for multiplex working, and cannot therefore take the place of the Baudot on heavily-loaded circuits. The receiving apparatus works in synchronism with the sending apparatus, and the messages are printed on a paper tape. The system has certainly some unique advantages, and it is unfortunate that it cannot be adapted to modern multiplex equipment.

The Teleprinter

In recent years the teletype, or, as it is usually called in this country, the teleprinter, has been supplanting the Hughes on international circuits. This apparatus consists of a typewriting keyboard transmitter and a printing receiver. The typewriter keyboard sets up the combinations of five units, and these impulses are transmitted direct to the line without the interposition of perforated tape. At the receiving end the messages are printed on tape, as in the case of the Creed and Baudot apparatus. It works up to 60 words a minute simplex or 120 duplex, and there is no doubt that this system will have a great future in developing the telegraph service of this country, where it is already worked on many important circuits which are not sufficiently loaded to require Baudot or other multiplex apparatus.

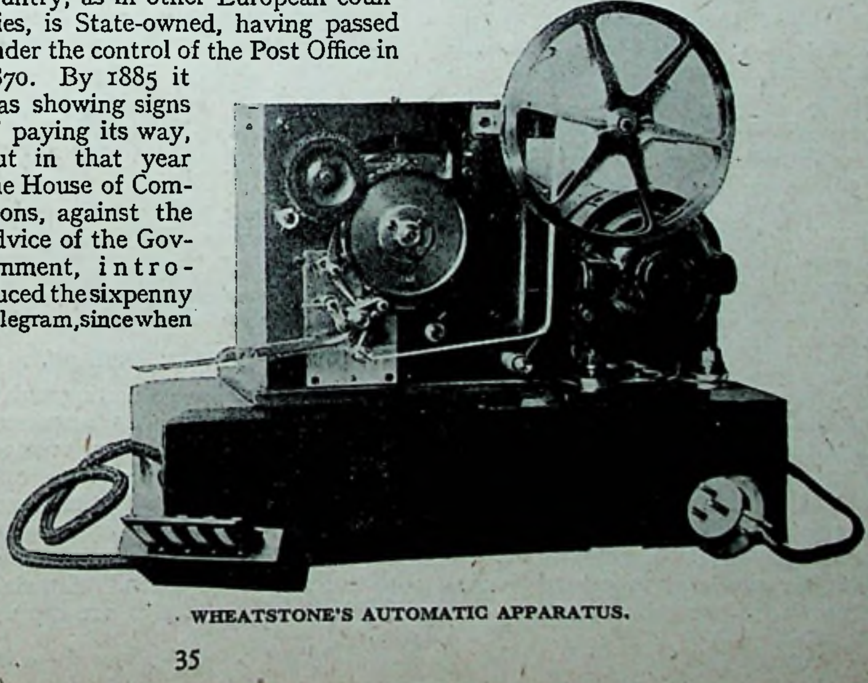
The Telegraph Service.

The telegraph service in this country, as in other European countries, is State-owned, having passed under the control of the Post Office in 1870. By 1885 it was showing signs of paying its way, but in that year the House of Commons, against the advice of the Government, introduced the sixpenny telegram, since when the service has never shown any signs of being a financial success. In 1920 the shilling telegram was introduced, but this doubling of the tariff has hardly counterbalanced the increased costs due to the war, and the decline of traffic, which latter is due mainly to competition from the telephone.

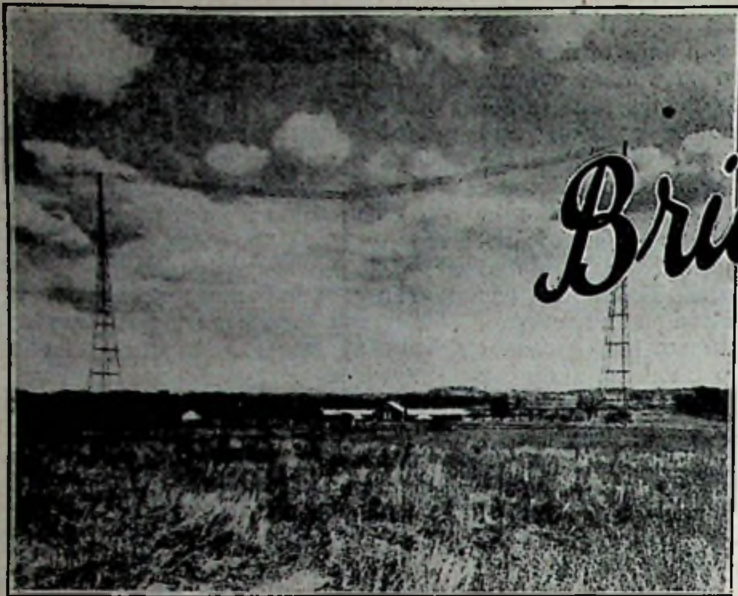
Facts and Figures.

There is, in fact, no chance of the telegraph service paying its way so long as wages and prices remain anywhere near their present level. The annual loss before the war was about £1,250,000, and it is now rather more. The traffic has dropped from about 94 million messages to about 64 million messages a year, but the ideal of service at which the Post Office aims remains unaltered, viz., **a really good service of uniform quality to all places, large and small,** and this, let if be noted, is an ideal of service which would not appeal to the shareholders of a commercial company.

IN his next instalment our contributor will commence to tell his readers in a brief but fascinating manner the history of the development of the submarine cable. He will give precise and authoritative information as to the importance and true meaning of submarine cables as they exist to-day.



WHEATSTONE'S AUTOMATIC APPARATUS.



Bridging Space

by JOHN WISEMAN

Part VIII.—MODULATING SYSTEMS

THE essential details necessary for obtaining an insight into the question of "modulating the carrier wave" were approached in a very simple manner last month, but it was pointed out that in practice a difference exists between the elementary case considered and the actual methods used for energising the transmitting aerial, and, of course, modulating the emitted wave. To keep within our original intention of dealing with principles we shall refrain from examining the various processes in detail, but, as was mentioned in the previous article, it is advisable to point out where the main differences exist.

The First Modification.

We saw that the simplest way of varying the aerial currents in accordance with the voice vibrations was to place the microphone directly in the aerial circuit, but the drawback here lay in the limitation of the transmitted power, owing to the small currents which can be handled effectively by the microphone. Some method of amplifying the "voice currents" must be incorporated, and a scheme for carrying this into effect for low power transmitters is illustrated in Fig. 1. The microphone is inserted in the primary circuit *P* of a suitable low frequency transformer and the secondary *S* of this same transformer is placed in the grid circuit of the oscillating valve, the condenser *C* shunted across the secondary terminals acting as a by-pass for the high frequency oscillations.

With the microphone idle the amplitude of the aerial current remains constant, but as soon as *M* is subjected to any form of excitation —speech, song, or music—then a varying current flows and a fluctuating voltage is produced across the extremities of *P*. This E.M.F. in turn is transferred to *S* by virtue of the magnetic coupling existing between the primary and secondary windings, and obviously this E.M.F. is a function of the vibrations of the microphone diaphragm.

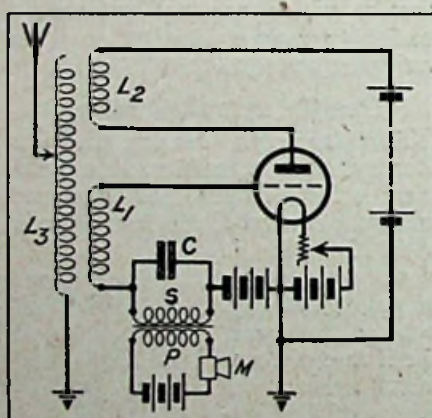


Fig. 1.
A method of modulation suitable for low-power transmitters.

An Impressed Voltage.

The grid of the oscillating valve, therefore, not only has impressed upon it the high frequency voltages due to the coupling between the coils L_1 and L_2, but also the low frequency voltages, and this latter increases or decreases the grid potential above or below its "idle condition." But since the coils L_1, L_2, and L_3 are coupled together, it follows that the aerial current and hence the transmitted waves will be altered in amplitude in accordance with the E.M.F. of *S*, that is, the vibrations of the microphone *M*. The frequency of the transmitted wave remains constant since this is governed by the high frequency oscillations generated through the medium of the valve, but we have brought about our modulation in a very simple manner.

Choke Control.

Obviously, from the very nature of the scheme discussed, the power output is still limited, although far in excess of that secured with the microphone directly in the aerial circuit, but for high powers, such as are used normally with broadcast transmitters, the arrangement gives way to that of Fig. 2. This second form of modulation is known as "choke control" and is a very popular and efficient scheme. In the schematic diagram of Fig. 2 the valve V_1 acts as the oscillator, while the valve V_2 is called the modulator.

Under steady conditions, or, in other words, when the microphone *M* is idle, the voltage difference across the points *A* and *B* is constant, and therefore the amplitude of the high frequency aerial current and in turn the carrier wave is constant. The plate current of the modulator valve under these conditions is also quite steady.

What Happens?

Now suppose that speech, song, or music is imparted to the microphone *M*. As before, we have a fluctuating

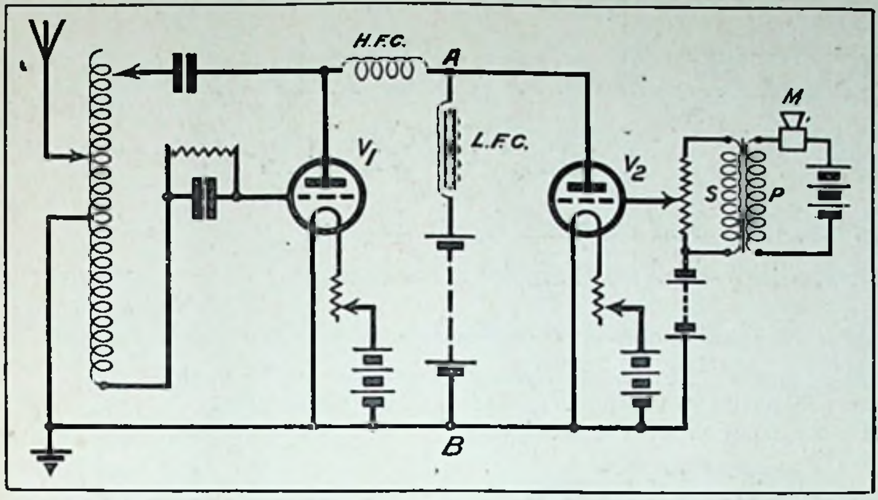


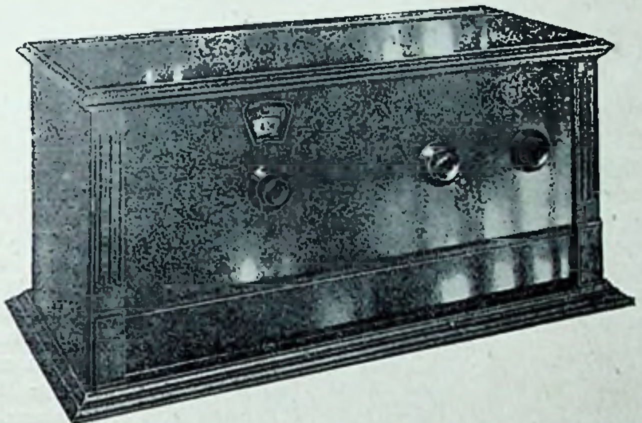
Fig. 2.
A method of modulation suitable for high-power transmitters.

voltage induced across the extremities of S, the secondary of the low frequency transformer coupling the microphone to the grid of the modulating valve. Now this alteration of modulator grid voltage changes the plate current through the valve V_2, the change taking place at a frequency within the acoustical range. In virtue of this the high-tension battery between the points A and B is called upon to supply a varying low frequency current, and since this must pass through the low frequency choke L.F.C. it will cause a large change of low frequency potential across its ends and thus between A and B. But this varying voltage is impressed upon the plate of the oscillating valve V_1, consequently the amplitude of the aerial current will be varied by the plate voltage change.

Greater Detail.

To examine this a little more closely: supposing that at a given instant the voltage of the grid of the modulator is increased owing to the vibrations of the microphone diaphragm. This rise in grid voltage causes an increase in plate current, and consequently the *actual voltage* imparted to the plate of V_1 is reduced owing to the increased loss of voltage or voltage drop across the choke L.F.C.

It follows, therefore, that any oscillations set up in the aerial by the valve V_1 will be modulated by the air waves imparted to the microphone diaphragm. The function of the coil H.F.C., which is an air core coil or high frequency choke, is to prevent the plate currents of the modulating valve taking from the aerial circuit any of the high frequency power which the oscillator valve is supplying to it.



A typical broadcast receiver.

The explanation above covers the main items of this important system without attempting to analyse the detailed working of its component parts. In practice there are other valves intermediate between the microphone circuit and the modulating valve connected to L.F.C., and these serve to amplify the speech fluctuations still more, which, of course, is an essential feature where strongly modulated high power transmitters are in use.

The Television Transmission.

Although during the course of this description we have referred to the methods adopted for transmitting speech or music, it should be understood that the televised scene is sent out in a similar manner. Instead of a microphone we have the photo-electric cells, which convert the light impulses into electrical impulses, and the latter are amplified and caused to modulate the carrier wave. As far as the "bridging of space" is concerned, we can regard the arrangements as being almost identical.

The Next Logical Step.

So far we have dealt with the electron theory together with lines of force and traced how wireless waves are generated, the functioning of oscillatory circuits, and how the aerial is evolved. Then we made our introduction to the valve, saw how it worked as an impulse timer, until now the stage has been reached when the high

(*Continued on page* 46.)

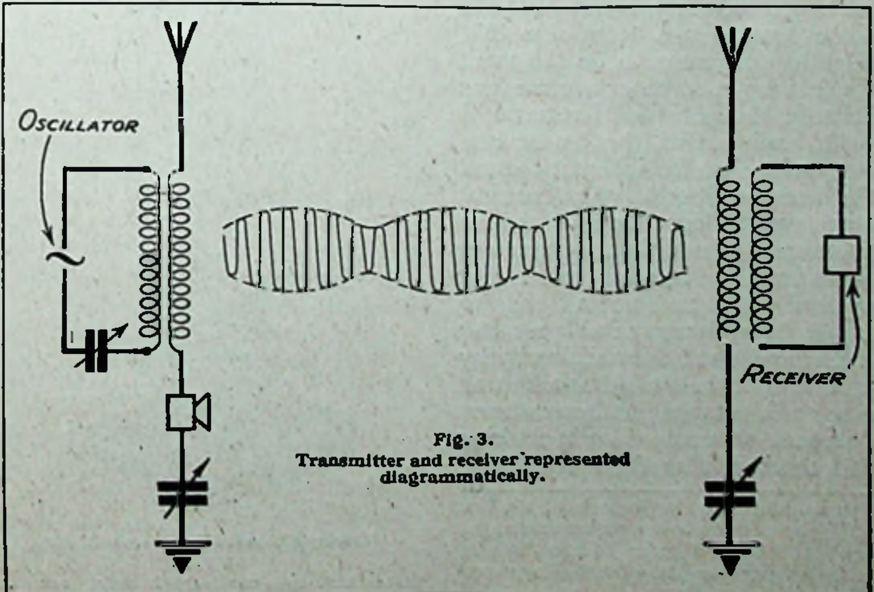


Fig. 3.
Transmitter and receiver represented diagrammatically.

THE CATHODE-RAY TUBE IN PRACTICAL TELEVISION

By W. G. W. MITCHELL, B.Sc.
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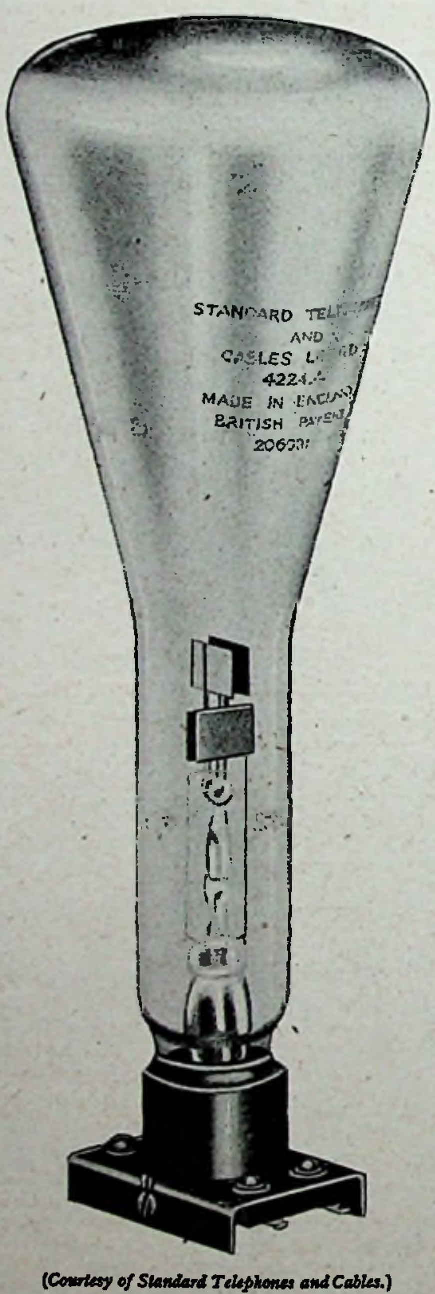
A NOTABLE date in the early history of television is the year 1881, for in March of that year Shelford Bidwell delivered his classical lecture on "Selenium and its Applications to the Photophone and Telephotography" at the Royal Institution in London, and at that time no one had experimented more with selenium than Shelford Bidwell. Moreover, it is as well to remember that the word "Telephotography," appearing in the title of the lecture, was used in a much wider sense than what it is at the present day.

But to the Abbé Caselli belongs the honour of having initiated the first practical experiments in sending simple designs over distances. This appears to have been accomplished by him as far back as 1862, and certainly the transmission of diagrams by Caselli's apparatus was in actual working between Amiens and Paris between the years 1865 and 1869. The discovery of the electrical sensitivity of selenium in the year 1873 is yet another landmark in the history of practical television, but it was not until 1908 (or thereabouts that the idea of harnessing a beam of mobile, weightless electrons to do the work of exploring a scene or picture was seriously thought of. Everyone, I think, realises that the "wear and tear," as well as the inherent natural "laziness," or inertia, of mechanical moving parts, constitutes a serious hindrance to the ultimate success of television in the broadest sense. For my own part, and not wishing to belittle the truly remarkable results* which have been achieved already by Baird, and at the same time admiring his splendid courage and the constancy of purpose shown by him in sticking to his mechanical methods, shall I say that against all I know has already been achieved, I would like to see the ultimate solution of the television problem come about through the agency of electrons.



(*Courtesy of Standard Telephones and Cables.*)
Fig. 1.
A cathode-ray oscillograph tube, complete with socket.

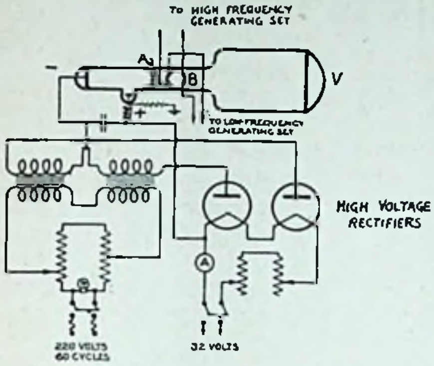
The harnessing of a beam of electrons may at first sight appear to be a comparatively simple matter, especially in view of the very definite progress which has been made since the days of the old Braun tube apparatus designed for that same purpose. There are, however, many practical difficulties which will have to be overcome before any definite progress can be made along these lines, and in the following pages I propose to deal with some of these difficulties and some of the suggestions which have been made, from time to time, for remedying them.

The Cathode-Ray Oscillograph.

Perhaps the best-known form of cathode-ray oscillograph is that shown in Fig. 1. A brief description, and comparison with the working of the Braun tube, will not be out of place. Like the modern gas-filled photo-electric cell, the oscillograph illustrated is a very sensitive instrument. The sensitivity has been increased, however, somewhat at the expense of reliability of action. When constructed, the tube is evacuated and the air replaced by a small amount of argon gas. The oscillograph differs, too, from the Braun tube in that the source of electrons is a hot filament instead of a high voltage gas-discharge. This fact makes it possible to operate the tube at a much lower potential than formerly. In the cold-cathode type of oscillograph several thousands of volts had to be applied to the cathode, and the electron stream thus excited was reduced by means of a diaphragm (with a single small aperture) to give a small bright spot on the fluorescent screen at the end of the tube remote from the cathode. Some of the tubes employed were 70 cm. or even a metre long. They generally had a high vacuum inside, which necessitated

* I am thinking particularly of the fine detail shown by the Baird apparatus at the demonstration given to members of the Television Society at the Engineers' Club at their meeting on December 4th.

the use of potentials of the order of 50,000 volts or more to produce a bright spot 1 mm. in diameter and to prevent spreading of the beam.



Cold-Cathode type of Cathode-ray Tube and connections, as used for standardising radio frequencies

Fig. 2.

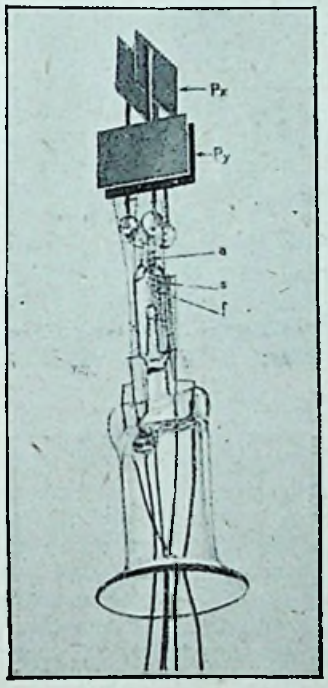
They certainly possessed one advantage over the modern tube—namely, that they were practically free from the tendency to "flash over."

In Fig. 2 a high voltage of about 20,000 volts is "stepped up" through the transformers shown, afterwards being rectified and applied to the negative end of the oscillograph tube, the positive side being earthed. Two baffle screens, marked *A*, are shown; so that when the projection of cathode particles is brought about by the high voltages applied, the cathode rays themselves are concentrated into a narrow pencil, or beam, and are rendered visible directly they strike the fluorescent screen at the further end (V) of the tube. In the ordinary way the beam appears centrally on the screen as a steady single bright spot.

Effect of Magnetic Field.

It is well known, however, that if an ordinary bar magnet is brought near the beam it will cause deflection of the rays. In actual working this deflection is caused by applying either electric or magnetic stress to the two pairs of plates mounted within the neck of the tube, through which the cathode stream must pass. In passing between the plates of one pair the electron stream is naturally deflected towards the positive plate of that pair. A second transverse deflection is brought about in passing between the second pair of plates, which are mounted at right angles to the first pair. So that, on viewing the end (V) of the oscillograph, we see appearing on the fluorescent screen, not a steady spot, but a bright moving spot whose rectangular co-ordinates at any moment are the resultant of these two deflections of the beam.

The detailed structure of a modern gas-filled cathode-ray tube is shown in Fig. 3. Electrons are thrown off from the oxide-coated filament or cathode *f* which is heated by an ordinary 6-volt accumulator. After leaving the filament the electrons pass through a small aperture in the metal shield *s*, which is there for the purpose of protecting the filament, as we shall see later. The cathode rays now pass through a tubular platinum anode marked *a* which is kept at a potential of about 300 to 500 volts



(*Courtesy of Standard Telephones and Cables.*)

Fig. 3.

Details of construction of oscillograph tube.

positive to the cathode. A battery of dry cells is quite suitable for the purpose. All that is necessary to obtain a bright concentrated spot on the fluorescent screen is a slight adjustment of the filament rheostat.

The tube, as we have seen, is filled with argon gas, so that during operation heavy argon atoms are directed backwards towards the filament. This filament (shown in more detail in Fig. 5), which fits snugly beneath its shield, is thus continually bombarded while the tube is working with those heavy argon atoms, and although the metal shield minimises the ill-effects of this bombardment, a useful life of more than 200 hours is seldom to be expected.

After passing through the anode the rays are shot between the two pairs of deflecting plates marked *Py*, *Px*. A diagram of connections is given (Fig. 4) and some photographic reproductions in Fig. 6.

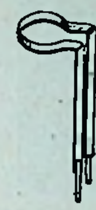


Fig. 5.

Construction of filament.

The pear-shaped tube itself is about 18 inches long. This apparatus has the great merit of requiring working potentials of only a few hundred volts, whereas previously many thousands were necessary, and consequently the auxiliary equipment is greatly simplified. Its useful life is very short when we are considering its possible usefulness in television problems.

On the other hand (moving parts being almost free from inertia) the oscillograph can easily and faithfully follow frequencies up to a million cycles per second. Essentially the cathode-ray oscillograph provides an easy means of deflecting a beam of electrons (in whichever way they are produced) in any desired direction. And this is done by applying either an electric or a magnetic field across the beam near its source. Deflection will occur in the same direction as the electric field and at right angles to the magnetic field.

Application of Principles.

We now come to consider the practical application of these principles to the problems of television, and the refinements which may be considered desirable before results of value can be obtained with the

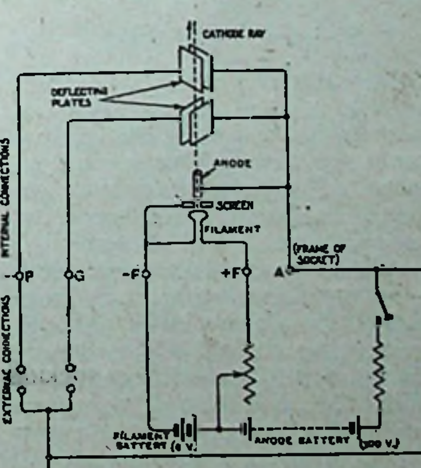
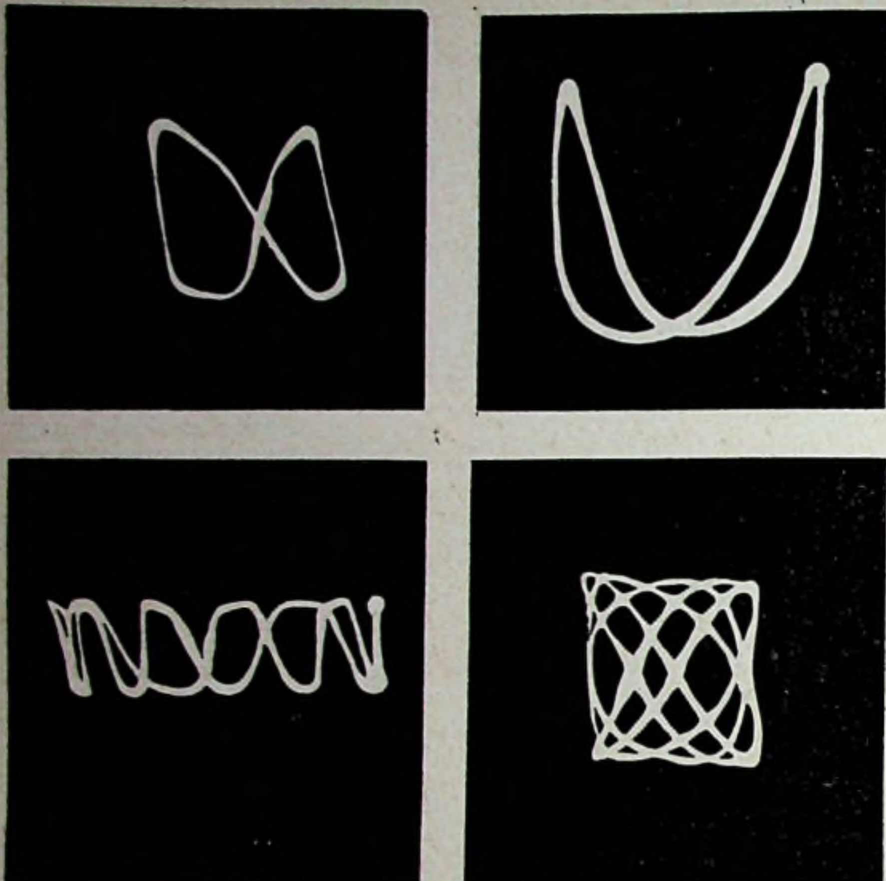


Fig. 4.

Diagram of connections of oscillograph tube.



(*Courtesy of Standard Telephones and Cables.*)

Fig. 6.

Photographs of some of the patterns seen on the screen of the cathode-ray oscillograph in making comparative observations of radio frequencies. These patterns are known as Lissajous figures.

apparatus. Provided only that we have a suitable ether link, we seem now to have succeeded in one bound, as it were, in overcoming one difficulty of television, namely, the immense speeds of signalling which are usually considered necessary. In other words, the time factor need worry us no longer.

Swinton and Rosing.

It was just over 20 years ago (June, 1908) that Mr. A. A. Campbell Swinton first suggested the employment of cathode rays for scanning an image. Nearly a year later the Russian scientist, Professor Boris Rosing, put forward a somewhat similar scheme. Nothing practical, however, seems so far to have resulted from these ideas, although several attempts have been made, and modifications of the original scheme of Mr. Campbell Swinton have from time to time appeared. Quite recently Dr. V. K. Zworykin (inventor of the photo-electric valve amplifier) has devoted some time to this same question, aiming particularly at securing natural colour effects.

If, then, we first of all turn to Mr. Campbell Swinton's original plan, which is to be found in his address to the Röntgen Society in 1911, we must be careful to remember that it was not claimed that the apparatus as described by him could be got to work satisfactorily without modification in details. The author was himself at some pains to make this fact clear to his audience. Nevertheless, the scheme shown in Fig. 7 (which is taken from the address just referred to) is of considerable practical interest. The tubes shown are of the old-fashioned cold-cathode type, and deflection of the cathode stream is brought about by applying the varying fields of two electro-magnets placed at right angles to one another and energised by two alternating currents of widely different frequencies, say 1,000 and 10 complete alternations per second. Some 100,000 volts must be applied for successful operation in securing a sharp point on the screen. *D*, D^1 and *E*, E^1 are electro-magnets which cause the vertical and horizontal movements of the beam, *D* and D^1 being fed from the same alternator, while *E* and E^1 are similarly fed from the same alternator *G*.

The point of interest now lies in the small metallic screen *J*. This, it should be pointed out, is "gas-tight," and is formed of a large number of very small metallic cubes, each carefully insulated from the others. These cubes are made of some metal such as rubidium (which is strongly active photo-electrically), so that they will readily release electrons when light is caused to fall upon them. On the other side of the screen is a chamber *K* containing a gas or vapour, such as sodium vapour, which is there for the purpose of assisting conduction of the electrons across the space to the metallic gauze screen *L*, more readily in the case of light patches of the screen *J* than in the case of dark patches.

How it Functions.

The whole apparatus is designed to function in the following way.

A uniformly steady beam of cathode rays is scanning one side of the screen *J*, while on the other side appears an image of the object, *N*, which it is desired to transmit. This image is projected by the lens *M* through the gauze screen *L* on to one side of the screen *J*.

Then, as the cathode rays oscillate and search out the surface of *J*, they will impart a negative charge to each little cell in turn. In the case of those cells brightly lit up on the reverse side, the charge will pass away through (and be assisted by) the ionised gas in

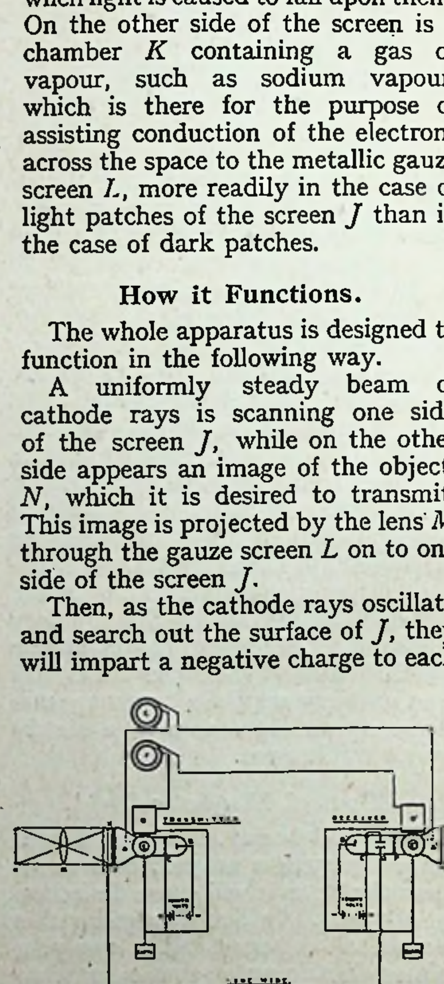


Fig. 7.

Diagrammatic representation of Mr. A. A. Campbell Swinton's suggested method of achieving television by means of cathode rays. The alternating current generators G and F oscillate the cathode beams emitted from B and B¹ vertically and transversely. Cells in the screen J, which are illuminated by the image, transmit potentials to the line wire which controls the passage of the beam through the aperture O at the receiver.

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Fig. 9

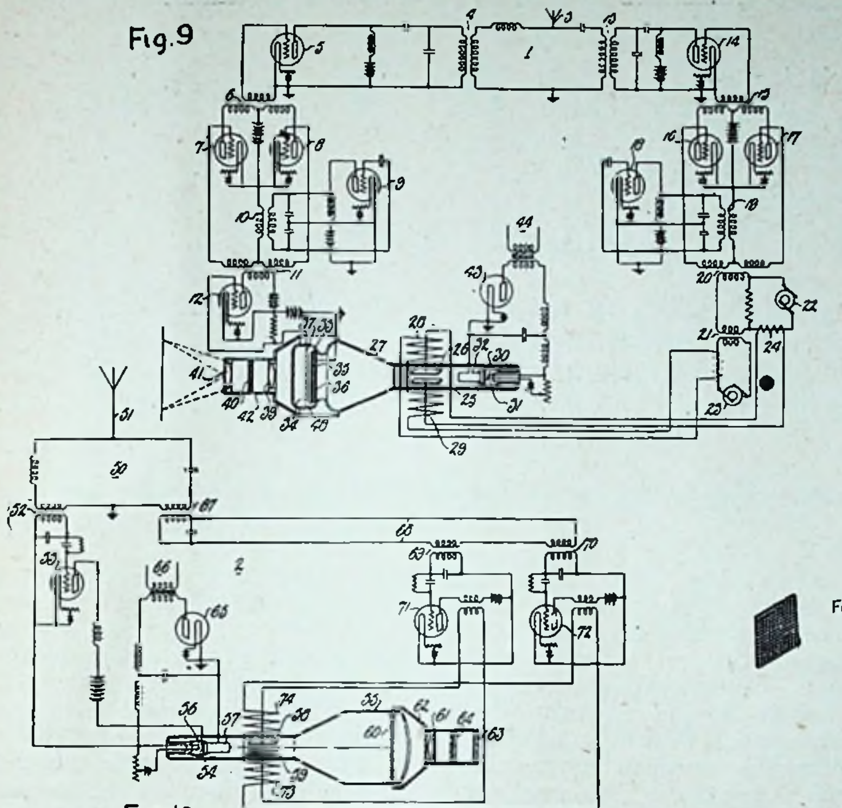

Fig 10.

Fig 8

Layout of Dr. V. K. Zworykin's Improvement on Campbell Swinton's scheme.

the chamber K, until it reaches the screen L. In the case of dark patches no further conduction will take place.

The actual method of controlling the cathode beam at the receiving end as it passes through the metallic plate O needs some elucidation.

Just beyond this plate, and nearer the viewing end of the tube, a diaphragm P is fitted, and so arranged that it will normally succeed in cutting off rays emitted from B^1, and so prevent them reaching the screen H unless they are slightly repelled from the plate O. The image signal coming through at any instant, in charging the plate O, allows the cathode beam to strike the screen H and momentarily produces a bright spot.

One objection which can be levelled at this interesting method of scanning is the poor definition which is likely to result from the "spread" of the conducting patch of ionised gas within the chamber K. This could, no doubt, be overcome by moving the screen L relatively nearer the plate J. On the other hand a particular advantage arises from the use in turn, one after the other, of many thousands of minute cells forming the screen J, for each cell is only called upon to transform light into electricity once every one-fifteenth part of a second.

Another practical difficulty arises in producing very narrow exploring pencils of cathode beams commensurable with the size of the individual cells forming the screen J. It seems possible to improve upon the arrangement of rubidium cubes; but the focussing of the rays to a *minute* spot on the screen H does not appear to be an easy matter, either from the point of view of obtaining improved concentration of the beam itself, or in the actual process of its impinging on a fluorescent screen.

Zworykin's Improved Scheme.

The improved scheme shown in Figs. 9 and 10 is due to Dr. V. K. Zworykin.* Fig. 9 indicates the schematic layout of a complete transmitting system and Fig. 10 the receiver. Wireless transmission is provided for and, further, a three-colour screen (shown as 40, 64 in Figs. 9 and 10, and in more detail separately in Fig. 8) is incorporated in the cathode-ray tubes with the intention of securing natural colour effects.

In addition, the original rubidium screen has been replaced by an arrangement of minute potassium cells. Otherwise the internal arrangements of the oscillograph tubes remain substantially the same.

It is not possible at the moment to give any details as to the actual results achieved by these methods. The matter is being actively pursued in the laboratory, and we shall certainly await results with the greatest interest. It remains to be seen whether the luminous intensity of the cathode ray, when projected at a potential of some 300 volts, and distributed over a large viewing surface, would be sufficiently bright to compare with the present known methods of integrating a television picture. If it does, then we shall have reached another landmark in the progress of television.

* In British Patent, No. 255057, granted to Westinghouse Electric Co. (U.S.A.).

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Light: The Essential of Television

Part VI.

By CYRIL SYLVESTER, A.M.I.E.E., A.M.I.Mech. E.

Light is one of the most important factors in connection with television, and one which must be carefully studied by all serious students of television. The principles and nature of light are by no means so widely known and understood as one would anticipate, and in this series of articles our contributor is elaborating them month by month.

ONE cannot determine the intensity of a light source by merely looking at it. It may be said, in fact, that most light sources which can be distinctly seen have an intensity so low that it cannot be measured. If one happens to be in flat country on a clear night the light from a candle in the window of a farmhouse can be seen over a distance of several miles.

From what we have already seen (in previous articles), the intensity of light from one candle would be approximately one foot-candle, and this at a distance of one foot from the candle wick. At this distance, or for a distance of a few feet further than this, the intensity could be measured; at a mile it could not be measured, even with the most sensitive instruments we have for this purpose.

Since, however, different intensities of light produce different effects upon the same object it is most essential that the necessary intensities of light (artificial light) to illuminate any object shall be predetermined. It will not be time wasted if I dwell a little upon the measurement of light.

The intensity of an incandescent lamp is not proportional to the amount of current passing through the lamp filament. This can be seen by experiment, by applying a low voltage to a lamp and increasing it until it is burning at rated voltage. Assuming the rated voltage to be 220 volts, the filament would not commence to glow until a potential of at least 60 volts is applied to it. The filament would appear to be dull red at a little higher voltage. As the latter is increased the filament becomes yellow, and, when full voltage is applied, practically white.

The spectrum of the light emitted from the filament varies with the increased voltage. When the filament is red it is the red rays which predominate; when it is yellow the yellow rays are more in proportion than the others. Although the yellow rays are the most intense rays

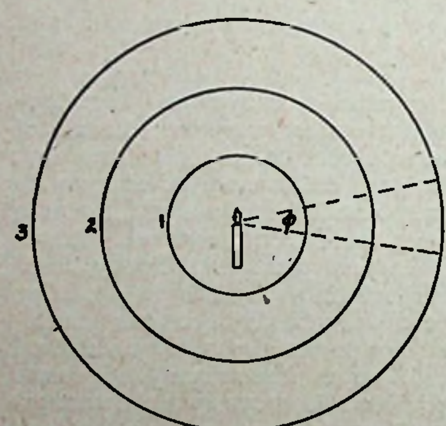


Fig. 1.

in the spectrum, these are useless for illuminating a setting which is to be broadcast. White light is the best light, with a certain proportion of red rays. The ideal is, of course, artificial daylight. This is white light which has been *corrected* for colour quality by passing it through a filter of a certain quality of blue glass.

Apart from colour quality, the intensity of light upon an object does not vary in proportion to the distance of the object from the light source. Let us consider Fig. 1, which we will assume to represent three hollow spheres (1, 2, and 3) placed one inside the other: the diameters of the spheres are 2 ft., 4 ft., and 6 ft. respectively. The candle in the centre of the inner sphere will be located at a distance of 1 ft., 2 ft., and 3 ft. from the inside of each sphere at *any point.*

If we imagine the angle Ø cutting through one square foot of the inner sphere, the intensity would be one foot-candle. If the angle is continued through the second and third sphere, it is obvious that, since a greater area is covered, the intensity of light will be lower than that on the square foot of the inner sphere. The area of the two outer spheres is four times and nine times, respectively, that of the inner sphere, so that it may be said that "The intensity of illumination received by a surface from a light source although directly proportional to the candle power, is inversely proportional to the square of the distance." In this way the illumination on the second sphere would be one-fourth of a foot-candle, and that on the outer sphere one-ninth of a foot-candle.

From this it will be seen that (considering bare light sources only):—

$$\text{Illumination} = \frac{\text{candle power}}{\text{distance}^2}$$

or $$\text{Candle power} = \text{illumination} \times \text{distance}^2$$

or $$\text{Distance}^2 = \frac{\text{candle power}}{\text{illumination}}$$

and $$\text{Distance} = \sqrt{\frac{\text{candle power}}{\text{illumination}}}$$

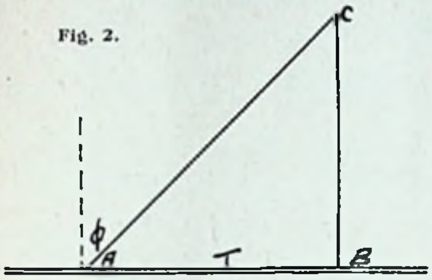
Let us work a simple example.

Example 1.—A 20 candle-power lamp is suspended at a height of

5 ft. above a table. Calculate the intensity of light on an object situated immediately *below* the light source.

$$\text{Illumination} = \frac{\text{candle power}}{\text{distance}^2}$$
$$= \frac{20}{5^2} = \frac{20}{25}$$
$$= 0{\cdot}8 \text{ foot-candle.}$$

Fig. 2.



Example 2.—It is desired to provide illumination of 2 foot-candles intensity upon an object on a table. If the power of the light source is 50 candle power, at what height must the source be suspended above the object ?

$$\text{Distance} = \sqrt{\frac{\text{candle power}}{\text{illumination}}}$$
$$= \sqrt{\frac{50}{2}}$$
$$= \sqrt{25}$$
$$= 5 \text{ feet.}$$

If the height were increased to 10 feet, and the same intensity of illumination was required, the candle power of the light source would be—

$$\text{Candle power} = \text{Illumination} \times \text{distance}^2$$
$$= 2 \times 10^2$$
$$= 2 \times 100$$
$$= 200 \text{ candle power.}$$

This is an example which illustrates the reasoning of Fig. 1. The height is doubled and the intensity remains

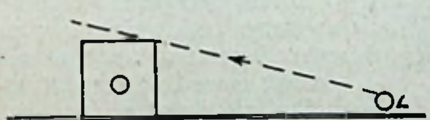


Fig. 3.

the same; the candle power must, therefore, be four times as great. This only holds good where the light source is situated immediately above the object to be illuminated. When the object and the light source are situated at an angular distance from each other, the matter becomes more complicated. Let us examine Fig. 2, where C is the light source, T is the table and A is the object. We will assume that the power of the light source is 1000 candle power, and that it is situated at a height of 10 feet above the point on the table, B. The intensity at B would be—

$$\text{Intensity} = \frac{1000}{10^2} = \frac{1000}{100} = 10 \text{ foot-candles.}$$

At point A, however, it will be—

$$\text{Illumination} = \frac{\text{candle power}}{AC^2}$$
$$= \frac{\text{candle power}}{AB^2 + CB^2}$$

If we assume A to be 30 feet from B, and using the same values as before, the illumination on a plane normal to CA will be—

$$\text{Illumination} = \frac{\text{candle power}}{AB^2 + CB^2}$$
$$= \frac{1000}{30^2 + 10^2}$$
$$= \frac{1000}{900 + 100}$$
$$= \frac{1000}{1000}$$
$$= 1 \text{ foot-candle.}$$

The illumination at A, on plane T, is—

$$\text{Illumination} = \frac{\text{candle power}}{\text{distance}^2} \times \cos \varnothing$$

where $\varnothing$ is equal to the angle ACB.

$$\text{Distance}^2 = AC^2$$
$$= CB^2 + AB^2$$
$$\text{Now, } AC = \sqrt{CB^2 + AB^2}$$
$$\text{and } \cos \varnothing = \frac{CB}{\sqrt{CB^2 + AB^2}}$$

If we now substitute for values, we find that the illumination at A is—

$$\frac{1000}{10^2 + 30^2} \times \frac{10}{\sqrt{10^2 + 30^2}}$$
$$= \frac{1000}{1000} \times \frac{10}{\sqrt{100 + 900}}$$
$$= 1 \times 0{\cdot}3$$
$$\doteq 0{\cdot}3 \text{ foot-candles (approx.).}$$

The calculations are even more complicated if the light sources are equipped with reflectors. The calculations we have already dealt with, however, will meet our requirements for the time being.

We have considered the intensity of light upon objects located immediately below a light source, and those situated at an angular distance. In practice, in any installation illuminating a number of objects or a setting, the illumination is obtained from a number of light sources located in various positions. In television, considerable care will have to be taken when locating light sources; much more so than is necessary in cinematograph settings. The correct amount of light and shade can only be obtained by the application of correct intensities of light in the right directions. This not only applies to the intensity of the light sources, but to the amount of illumination received from objects with certain reflection factors.

Let us consider Fig. 3. Here a light source, L, is illustrated in the horizontal plane with an object, O. If this source and the object are situated in a room where the walls have a low

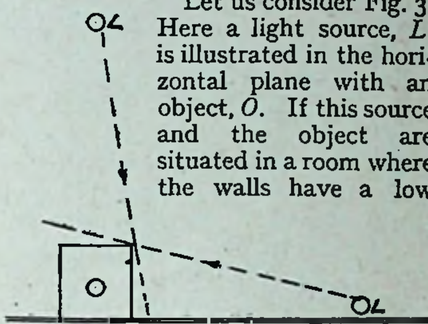


Fig. 4.

reflection factor, only one side of the object will be illuminated; the side nearest the source. The object would not have shape under this condition. If another source is situated immediately above the object, as illustrated in Fig. 4, the top of the object would be illuminated, making, in all, an illuminated top and side.

If the source above the object is fitted at the same distance as the one at the side (and the candle power of each source is the same) the top of the object will be illuminated to the same intensity as the side, so that, looking at the object from certain positions, both top and side will appear flat. If the lamp above the

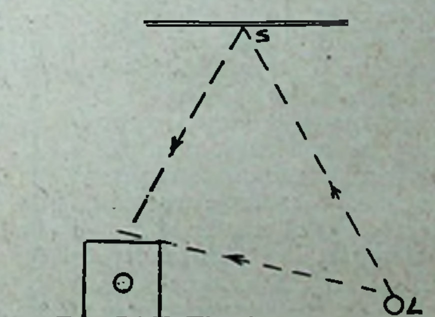


Fig. 5.

object is raised, the intensity will be lower on the top than on the side, and the object, from the two illuminated sides, will commence to take *shape*.

From this it will be seen that, to obtain the correct amount of light and shade for broadcasting, the

(*Continued on page* 45.)

Further Notes on Accumulator Charging

By W. C. FOX

In our January issue we published a very interesting description of a method of keeping L.T. accumulators charged without worry or trouble. In the following article our contributor adds a few more notes on the subject, and also describes how the method can be applied to keep H.T. accumulators charged as well.

THE small accumulator charger described last month must have made many users of high-tension accumulators feel disappointed that their interests were not catered for. I owe them an apology, for having discarded such small cells and installed an eliminator instead they escaped my attention.

Before describing the H.T. charger, which is substantially like the charger described last month, there are one or two points that may be of interest in connection with the latter piece of apparatus.

I hope those who have built up the charger have got it going satisfactorily—there are no "snags" anywhere in its construction—and have chosen the baretter method of limiting output. This, quite apart from its automatic control of output, definitely prevents the arc in the rectifier striking in a reverse direction and discharging the accumulator, supposing through some chance the rectifier valve should be moved into a magnetic field with the charger hooked up to the cells.

After use a grey deposit may be noticed around the bottom of the inside of the rectifier. With further use this deposit will condense into small globules of bright silvery-like metal and eventually be found in the bottom of the valve. This need cause no alarm, for it is merely the mercury, the vapour of which, together with sundry inert gases, fills the bulb.

As the mercury condenses into larger and larger globules it may be noticed that the change from the violet-blue glow which accompanies the striking of the arc, to the intense, characteristic bluey-green of the mercury arc when the valve has been running for some minutes, takes longer than formerly. If it is desired to bring things back to their original condition, and at very long intervals it may be necessary, it is done by removing the valve from its socket, gently reversing it and swishing the globules round the top end, trying as much as possible to avoid depositing any mercury on the filament.

It is *just* within the range of possibility that a particularly large globule of mercury may become entangled in the coils of the filament and cut out enough of it to cause the remainder, when the current is switched on, to fuse.

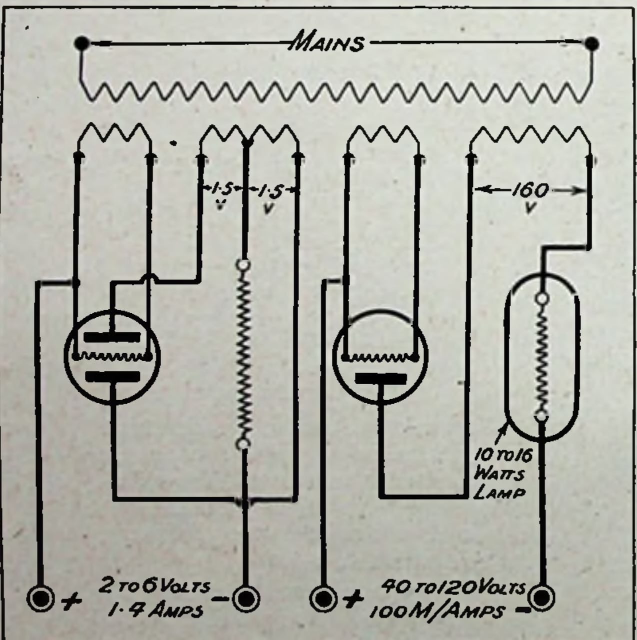


Diagram of connections of the combined charger for both L.T. and H.T. accumulators.

The intermittent shaking valves receive in transport is sufficient to prevent this lodgment, and the possibility of a filament being burnt out through this cause is mentioned more to settle undue anxiety when it is realised there is free mercury in the bulb than from any need to warn one to be careful and not let it happen.

Ardent experimenters (and those who are experimenting with television should be) may find that once the arc has struck they can switch the filament off and the valve will continue to rectify. This will be no new discovery. The fact is well known, but the filament is left on for a very definite purpose.

If the filament is only left heated until the arc has fully struck the whole of the rectifying effect takes place on one very small section of it to the untimely destruction of the whole filament. With the filament steadily heated the whole time, rectification is distributed over its entire length in synchronism with the alternating current flowing through it. Therefore, don't try to save the trifle of current required to heat your rectifying valve filament.

So much for the rectifying valve. Now for the charger for H.T. accumulators and, despite the apparent neglect of last month, there is probably no form of accumulator in general amateur use that will benefit more from the installation of a charger.

Small accumulators of the H.T. class are particularly prone to troubles consequent on their small size and the long periods between their recharging.

From this cause alone the plates at the bottom of the cells often disintegrate.

The trouble is due primarily to the electrolyte being stagnant in the cells. The acid as the heavier component settles to the bottom, with the result that the plates at that spot are subject to the action of strong acid. Frequent recharging stirs up the acid and prevents this settlement.

What may or may not happen to small cells in the hands of the average commercial charger one cannot say, but it is safe to assume that gross overcharging and careless "topping up" are two of the ills they have chiefly to withstand.

Charger Pays for Itself.

For these reasons alone a charger will pay for itself, not to mention the satisfaction of knowing that one's cells are being properly treated and are up to their work.

The general lay-out of such a charger is very similar to that of the charger described in the last issue, except that a single wave rectifying valve is used with an ordinary resistance lamp in the negative lead in place of the baretter.

The half wave valve requires about 1·8 volts at 2·8 amperes to light the filament, with about 160 volts on the plate, and gives about 100 milliamps. of rectified current. The resistance lamp, which can be of the ordinary illuminating type, should have a consumption of about 10 to 16 watts, or a lamp constructed specially for the purpose can be purchased.

If one really means to stick to small accumulators for H.T. supply purposes, and in some cases in television work they are very pleasant and simple and free one from a number of small circuit complications, the two chargers already mentioned can be combined into one unit and all cells charged up at the same time.

The Circuit Diagram.

A diagram of this circuit is given, and it will be seen that it is essentially the two chargers placed side by side drawing their requirements from a common mains primary.

Either the H.T. or L.T. side can be used separately or both can be on together.

With regard to building up it can be treated in exactly the same way as the simple charger already described, and is as essentially reliable.

If one is really content with accumulators for all purposes it offers the simplest and cheapest way out of the re-charging difficulty, for its cost is in the neighbourhood of £3. The parts can be purchased from the firms already mentioned last month.

Sooner or later, however, the claims of mains working for H.T. supply are sure to rise superior to all arguments, and it is for this reason that H.T. accumulator charging was not mentioned in the original article. The question of building a mains H.T. unit entails special problems of its own, and these, together with a description of a particular unit, will probably form the basis of a future article.

Light: The Essential of Television.

(*Concluded from page* 43.)

intensity of light from various directions will vary considerably. Mobile lighting units will be called into service by means of which the intensity in certain directions can be varied at will. In many cases the problems will be solved by fitting screens having high reflection factors in certain positions, so that some of the light incident upon them is redirected in definite directions. This is illustrated in Fig. 5. Here we have a light source, *L*, a screen, *S*, and an object, *O*. The side of the object is receiving direct light, and the top of the object reflected light. This is, in effect, the condition illustrated in Fig. 4.

We will next consider the lighting of a setting which contains several objects with high reflection factors.

Simple Two-Lens Optical Systems.

(*Concluded from page* 24.)

length of the lens *B* is less than that of the lens *A*, and the focal point F_1 is superposed on the focal point F_2, is that of the famous telescope invented by Galileo in 1610. So adjusted, parallel rays entering the telescope emerge as parallel rays—the condition to be satisfied for a sharply focussed telescopic image.

In the early part of the seventeenth century this form of telescope, with its draw-tube extended, and, therefore, with an optical separation between the object-glass and the ocular, was used, as what would now be called a telephoto lens, to project images of celestial objects on to a screen for examination; and it was with such an adjusted telescope, fixed in a hole in a window shutter, that Jeremiah Horrocks, a Lancashire curate, on Nov. 24th, 1639 (O.S.), was the first to observe a transit of Venus across the face of the sun—a transit which he himself had predicted.

The Story of Chemistry.

(*Concluded from page* 14.)

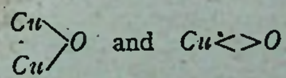
form acids with water, others form bases, and they are said to be typical oxides. There still remain oxides, however, which do not behave in this way.

A few, such as water, the oxide of hydrogen (H_2O), carbon mon-oxide (CO) do neither. They are termed *neutral oxides*. A further subdivision contains many important substances and are known as *per-oxides*. The molecules of the per-oxides contain a greater percentage of oxygen than the typical oxides. Thus the typical oxide of sodium has the formula Na_2O, while sodium per-oxide has the formula Na_2O_2. These per-oxides are characterised by the fact that they will readily part with their extra oxygen, and thus revert to typical oxides. The molecules seem to be "overcrowded" and to favour "emigration" of the "surplus population." The per-oxide molecules are not such stable arrangements as the typical oxides.

Per-oxides.

It is not always possible to pick out per-oxides from the formula. Thus sulphur has a typical oxide, sulphur dioxide, which produces an acid with water and has the formula SO_2. There is, however, another oxide having the formula SO_3, which at first sight might be mistaken for a peroxide. Sulphur trioxide, however, behaves quite normally with water, also producing an acid, and thus is a typical oxide. In the same way copper possesses two oxides—one red coloured, one black. They have the formulæ Cu_2O and CuO, but both are typical oxides producing bases.

Here we have a question of valency. Both sulphur and copper, and other elements too, have the power of acting under one set of condition with one valency, and under other conditions with another valency. Thus in cuprous oxide (Cu_2O), the red powder, copper has a valency of one, while in cupric oxide (CuO), the black substance, it has a valency of two, thus—



To use our old analogy, the copper atom uses one "hook" when making cuprous oxide, and two when making cupric oxide. These two oxides are quite distinct compounds, and the bases which they form are likewise different.

BOOK REVIEW

CONDUCTION OF ELECTRICITY THROUGH GASES.—By Sir J. J. THOMSON, O.M., F.R.S., and G. P. THOMSON. (Third Edition, in two volumes.) Vol. I.—The General Properties of Ions; Ionisation by Heat and Light. Cambridge University Press. 1928. 25s. net.

THE authors of this book are experts on the subject about which they write: Sir J. J. Thomson—who discovered the electron—and his son, G. P. Thomson. Of the son (G. P. Thomson) I well remember Sir Oliver Lodge saying at the last British Association meeting at Glasgow: "Watch him, he is a genius." In this masterly survey on the subject of discharges in gases we therefore have the highest authorities on the subject as our guides.

It should be said at the outset that this book is a standard work of reference; it is essentially a book for study and in parts is highly mathematical. It is really a comprehensive summary of the work of such men as Rutherford, C. V. Boys, Millikan, Elster, and Geitel (the names seem inseparable in this branch of science), Moseley, C. T. R. Wilson, Langebin, Aston, Hallwachs, and the authors themselves. The book resounds with these names, which in itself is a sufficient guarantee of its authoritativeness.

To our readers probably the last chapter on ionisation by light and photo-electricity will be the most interesting part of the book. The earlier chapters deal with electrical conductivity of gases in the normal state, where we read "the conducting gas loses its conductivity if it is sucked through a plug of glass wool or made to bubble through water."

In the next chapter on the properties of a gas in the conducting state it is made clear that the current does not obey Ohm's law unless the E.M.F. acting on the gas is very small. Chapter 3 is devoted to the mobility of ions, and numerous methods of measurement are given and the results compared. Then follows a close mathematical treatment of the theory of conduction through a gas containing ions. Aston's mass spectrograph, which can be used for determining the ratio of the charge to the mass of an ion, is described on page 276.

The importance and the beauty of the apparatus designed by C. T. R. Wilson for showing the track of α rays, or fast electrons, as a line of drops, is rightly emphasised and illustrated by photographic plates.

We might point out that on page 364 "Western Electric Co." should read "Standard Telephones."

In a list which is given of metals arranged in order of their power of discharging negative electricity, rubidium and potassium come first, then an alloy of sodium and potassium, then sodium, lithium, magnesium, thallium, and lastly zinc.

A fairly complete summary of the principles underlying the action of photo-electric cells is given in the last chapter, including references to the energy of emission of photo-electrons and the threshold wavelength below which the cells are insensitive. In this latter connection it is pointed out that the photo-electric threshold of metals varies very greatly with the extent to which they are freed from gas by heating *in vacuo*.

Altogether the work is a masterly treatment, running to some 500 pages and covering a very wide field of increasing importance in science. It is essentially a book to read and re-read and then to use for reference, which is made easy by the very comprehensive index provided.

W. G. W. MITCHELL, B.Sc.

Bridging Space.

(*Concluded from page* 37.)

frequency oscillations are modulated and sent out into space as carriers of speech, music, song, or televised scenes. Our next logical step is to transport ourselves to a receiving station and see how we can reconvert our modulated wave into intelligible sound or vision.

Diagrammatically our position is represented by the simple scheme shown in Fig. 3, and, as would be expected, many of the fundamental principles we have dealt with previously apply with equal emphasis at this end of our system. Although the energy that is absorbed actually at the receiving station is only a feeble residue of that transmitted, since the waves in space have spread far and wide, yet since they preserve all their peculiarities intact every pulse of the speech, etc., is retained and can be reproduced, and by adequate magnification is rendered audible.

What is Needed.

Actually we shall need an aerial system to "pick-up" the signals in a manner which we shall examine very closely and some form of apparatus which will enable the minute voltage changes in the aerial to be "rectified" and then "amplified." To the average wireless listener, therefore, we now approach a stage with which he has had a certain amount of practical experience. While a knowledge of the internal workings of the receiving set and its associated apparatus is not altogether essential since the components can be taken and used without concerning oneself about their natural functions, such a delimitation is obviously undesirable. The receiving set can just be a "box of tricks" with one or two knobs to turn as in the instrument illustrated in the accompanying photograph, but we are seeking something which lies a little deeper below the surface.

A perusal of the pages of TELEVISION has taught the reader that all the cognate subjects must be appreciated to a certain degree if reliable results are to be achieved, so next month we will apply the knowledge we have garnered in the present series to an analysis of what actually happens from the moment the transmitted wave strikes the receiving aerial.

My Letter to the B. B. C.

By NOËL SWANNE.

MARJORIE said I had better do something about it, and when Marjorie says—well, anyway I have written to the B.B.C.

At least, I shall have written to the B.B.C. when one or two minor difficulties have been overcome. First of all, it is difficult to know quite how to begin. A "corporation" is a funny thing. I began:

"My dear Mr. Mayor,"

Marjorie was sure that was wrong, and that they did not keep a Town Clerk either. For the present I have left that point over. Finally, I expect I shall say just "Sir."

It seemed to me that I ought to open on a friendly note. They know me very well at Savoy Hill. Several of the announcers say, "Good night . . . good night" to me. So I opened thus:

"You will remember, when on July 23rd I took out my licence for a receiving set. . . ."

"Our Friend Mr. Swanne."

That gets down to the friendly touch at once. I can picture the scene. A long room, a long table, long windows, long shutters, so that all is dark, for the B.B.C. do not like seeing things. Then a little red light flashes, and everybody says, "Sssssssh!" A pleasant voice then begins, "Mr. Chairman and Corporation—a letter from our friend Mr. Swanne. We all remember that on July 23rd. . . ." Red, blue and green lamps will flash out along the long table, and a stationary wave of friendliness (732.658 m.) will be formed.' You see the idea.

Next, I want them to know that they are dealing with a person who knows what he is talking about. Marjorie says this will be difficult. Still, I shall be a little technical, thus:

"About this overcrowding of the ether. You know, the same trouble arose at the pit and gallery entrances owing to the dense crowd of patrons of dramatic art, who were struggling to find out how many garments the leading lady would discard by Act III. The queue system saved the situation, and doubtless the application of something similar would deal with your trouble. I have no objection to training a few spare waves in the art of queuing-up."

After that they will be prepared to listen, while the announcer gets on with the rest of my letter.

"The Clarion Call."

"Speaking as man to man," I shall write, *"and voicing the opinion of the general public, the time has come, when you should recognise the clarion call that resounds from one end of our mighty Empire to the other end. Flappers have now got a vote. You must remember that, and throughout our land there are millions of flappers languishing for love of those lovely voices, which tell us that a depression is moving off to Iceland."*

I hope you will notice the very subtle introduction of a political atmosphere. Then I shall go on—

"Homes are being ruined. There has only been one wedding in South Mimms for two years. Why? Because every flapper is hoping that someday she will meet an announcer, and be lulled to sleep by the sweet cadences of his lovely voice."

It is quite possible at this stage that one or two silent tears will fall on to one of those red lamps. Perhaps one of them will crack, and the Chief Engineer will deal with the situation in a highly technical manner.

"This cannot go on. The Empire is tottering. Old England and South Mimms must be restored to the happiness of wedding bells, and the consequent increase of population thereby entailed. Otherwise, in time there will be only one person to buy a licence, and what would you do then, poor things."

Marjorie says that she is not quite sure that that is nice. Well, one can't be too particular when big stakes are at issue.

"To you, then, sir (or gentlemen, or dear corporation) comes a duty to perform. I admit that you cannot engage a special charabanc, and take the body of announcers round South Mimms and the rest of the Empire, but at least you could show them to the eagerly waiting mass of above-mentioned flappers. That might put the flappers off their food for a day or two, but that would not matter. In a short time I should be writing to the Press complaining of the annoyance of the persistent ringing of wedding bells."

Marjorie, of course, saw the flaw in this argument, but I met it by a masterly paragraph.

"Of course, should your committee (commission, junior corporation) appointed to carry out this work find that any or every of the aforesaid announcers were of such personal appearance as should tend to aggravate the trouble, then the aforesaid announcer, or announcers, would have to be shown together with a suitable wife and happy family, and so deal a death-blow to aspirants."

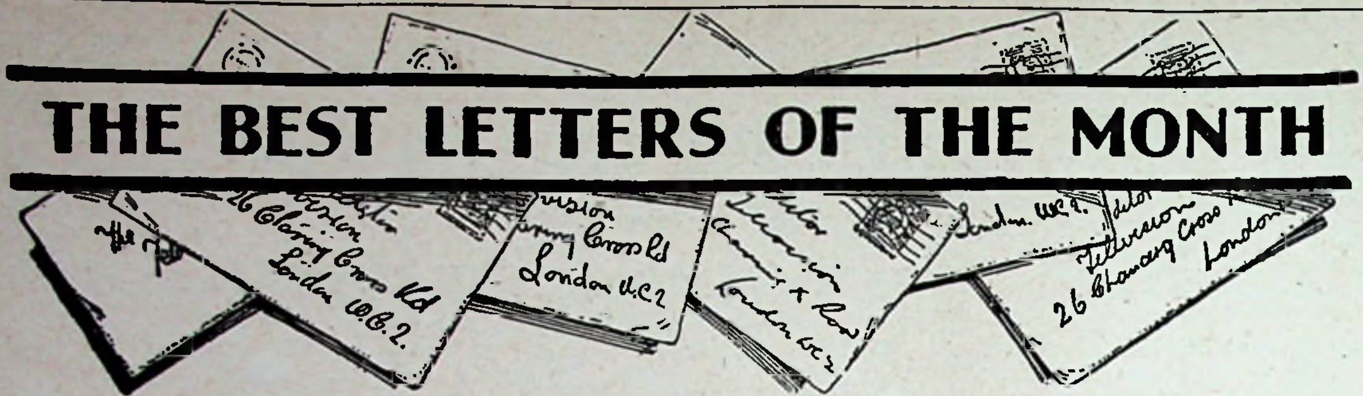
"A Friendly Ending."

Then I think I should end gracefully, with compliments or something like that—quite a friendly ending anyhow. I feel sure that they would all feel that it was up to the corporation to corporate, or whatever it is that a corporation does. There might be a difficulty, of course. They might sigh and say, "How is this thing to be done?" and no one would answer. I have provided for that by a neat little postscript:

P.S.—I understand that a gentleman named Baird would be willing to help you in showing these things to the Empire and South Mimms.

So Mr. Moseley need not get angry with anyone any more. It will be quite all right after the B.B.C. gets my letter.

THE BEST LETTERS OF THE MONTH



The Editor does not hold himself responsible for the opinions of his correspondents. Correspondence should be addressed to the Editor, TELEVISION, 26, *Charing Cross Road, W.C. 2, and must be accompanied by the writer's name and address.*

MR. ADCOCK'S SUGGESTIONS.

HEADINGLEY, LEEDS.
January 5th, 1929.

DEAR SIR,

I have followed with interest the discussions raised by your correspondent, Mr. E. P. Adcock, but I would like to point out that, as I read it, Mr. Adcock's suggestion is based on at least one false assumption. His original idea of using a copper plate as the medium for effecting the transformation of light reflected from the object into an electric current assumes that each infinitesimal area of the plate, and the current which it produces, can be differentiated from its neighbour, whereas it is obvious that without some mechanical scanning device the current produced by the plate would be representative of the sum total of the currents produced in each small area of the plate, by the varying intensities of light and shade received on the plate from the object. This would then appear at the receiver as a light having no shape or outline whatever, being in fact just an electric current representative of the object as a whole, and unable to differentiate between the various composite parts.

In his letter reproduced in your January issue, Mr. Adcock has made the unfortunate assumption that one can change the *frequency* of a light wave by altering its *velocity*, though I admit that it is possible to reduce the velocity of light by causing it to traverse a medium more dense than that in which it finds itself at present. Thus we see that it is not possible to change the frequency of a light wave in the manner suggested by your correspondent.. If this were possible it would mean, of course, that we could, by passage through a sufficient thickness of denser medium, change the colour of, say, red light to green light.

By way of analogy, consider the ease with which we change the quantity of electricity flowing in a circuit. This needs only an increased resistance to diminish the "velocity" or quantity of electricity, but, on the other hand, if we desire to change the frequency by even a small amount we are faced with an entirely different problem, though of course one not incapable of solution.

Yours faithfully,
H. WOLFSON.

MR. J. B. SHREWSBURY'S ARTICLE.

MIDDLESEX.
January, 1929.

DEAR SIR,

Mr. Shrewsbury's article in the November number certainly suggests interesting problems. The gist of his idea seems to be that a telescope objective, specially designed to focus wireless instead of luminous waves, might be used as a television receiver, if means could be found to transform the image (analogous to an optical image) thus obtained in the focal plane into a visual picture. A new method for increasing the amplitude is also postulated. An ordinary visual telescope, though giving television of the moon, cannot of course be employed for long distance transmission along the earth's surface, because the rays of light will not bend round the earth.

There are one or two points in connection with the subject that have not been mentioned by previous correspondents. The lifelike impression produced by a picture depends to a considerable extent upon the shadows. It is well known that light can travel round a corner, though for a distance only a finite fraction of a wavelength. This invasion of the shadow, which is due to minor disturbances along the borders of the main wave, though negligible in the case of visual waves, becomes serious when dealing with waves metres long. All small shadow detail will then be, not merely altered, but completely obliterated.

A surface acts like a polished mirror towards light if the wave-length is over eight times the depth of the surface corrugations. Even deep red rays are sometimes regularly reflected instead of being scattered by smoked glass. Pictured by means of wave-length three centimetres, cloth would seem like smooth glass; while with wave-length three metres, a cabbage field would appear as a lake. Thus even if an observer succeeded in obtaining an image with his receiver by the proposed method he would need considerable experience to identify it.

Another point is that, since the focal length of a lens is a function of the wavelength, in the case of long waves slight variations of frequency in the supply might have great effect on the focus. This remark would not apply to a reflecting telescope. For open-air scenes the introduction of a camera and collimator at the transmitting station seems a needless complication; a racegoer anxious to get a good view of the Derby would not direct his binoculars at the focussing screen of a camera on the ground.

TELEVISION grows more thrilling every month. Wishing it a prosperous New Year,

Yours faithfully,
(MISS) A. EVERETT, M.A. (F.Tv.S.).

DE QUINCEY FORESAW TELEVISION.

NEWCASTLE-ON-TYNE.

DEAR SIR,

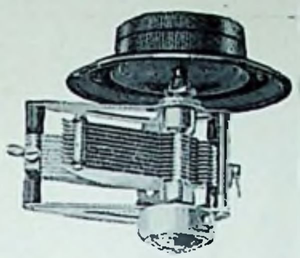
With the end of the first volume of TELEVISION I think we should congratulate the editor and his staff upon maintaining a very high initial standard of technical and literary merit in its production, especially as entirely new ground had to be broken.

Many quotations have appeared from time to time in the Press purporting to show how some of the great poets and literary masters of the past "foresaw" the wonders of wireless telephony, but, refreshing my mind during the Christmas period by dipping into the "great" once more, I came across this extract from "Travelling in England in the Old Days," which Thomas De Quincey (the English opium-eater) penned in the eighteen-fifties. He seems to have visualised what Mr. J. L. Baird has now actualised. De Quincey was lamenting the slowness and cost of travelling facilities which prevented persons or nations from meeting more freely, and he went on—

> "But, as the system of intercourse is gradually expanding, these bars of space and time are in the same degree contracting until finally we may expect them altogether to vanish; and then every part of the empire will react upon the whole with the power, life and effect of immediate conference amongst parties brought face to face. Already a prefiguring instinct spoke within me of some great secret yet to come in the art of distant communication. At present I am content to regard the electric telegraph as the oracular response to that prefiguration, but I still look for some higher and transcendent response."

It is up to this later generation to see that no vested interests stand in the way of humanity both hearing and seeing through the magic ether.

Yours faithfully, A. S. REEVE.



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